PB-240 075

RADIOLOGICAL HEALTH DATA AND REPORTS. VOLUME 12, NUMBERS 1-3, JANUARY - MARCH 1971

Public Health Service
Washington, D. C.

March 1971

DISTRIBUTED BY:

NTIS
National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

BIBLIOGRAPHIC DATA SHEET	**1. Report No.** RHDR 12 (1-3)	**2.**	PB 240 075

4. Title and Subtitle
Radiological Health Data and Reports
Volume 12, Nos 1-3

5. Report Date
Jan-Mar 1971

6.

7. Author(s)
None

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
U.S. Department of Health, Education, and Welfare
Public Health Service
Washington, D. C. 20201

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
U.S. Environmental Protection Agency
Office of Radiation Programs
401 M St., S. W.
Washington, D. C. 20460

13. Type of Report & Period Covered
Final: Jan-Mar 1971

14.

15. Supplementary Notes

16. Abstracts

Data and interpretation of data on radiation exposure to humans and on radioactivity in milk, water, air, and other environmental media are presented. in 24 volumes. For prices of individual issues, see below!

17. Key Words and Document Analysis. 17a. Descriptors

Radiation
Radioactivity
Air
Water
Milk
Food
Human

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
US Department of Commerce
Springfield, VA. 22151

PRICES SUBJECT TO CHANGE

18. Availability Statement Release unlimited	**19. Security Class (This Report)** UNCLASSIFIED	**21. No. of Pages** 175
1	**20. Security Class (This Page)** UNCLASSIFIED	**22. Price** PC / MF 6.25 / 2.25

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 12, Number 1, January 1971

Radiological Health Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Environmental Protection Agency
Atomic Energy Commission

CONTENTS

Page

REPORTS

Estimates of Potential Doses to Various Organs from X-radiation Emissions from Color Television Picture Tubes 1
R. H. Neill, H. D. Youmans, and *J. L. Wyatt*

Surveys of Radium Contamination in Aircraft Instrument Repair Facilities, 1966–1967 7
G. D. Schmidt, J. A. Halperin, E. Geiger, and *W. Livingstone*

Environmental Survey of Uranium Mill Tailings Pile, Mexican Hat, Utah 17
R. N. Snelling

DATA

SECTION I. MILK AND FOOD 29

Milk Surveillance, September 1970 29

Food and Diet Surveillance 38

1. Radionuclides in Institutional Diet Samples, April–June 1970, *PHS* and *FDA* 39

Carbon-14 and Tritium in Total Diet and Milk, January 1969–June 1970, *PHS* 42

SECTION II. WATER 45

CONTENTS—continued

Page

SECTION III. AIR AND DEPOSITION 46

Radioactivity in Airborne Particulates and Precipitation 46

1. Radiation Alert Network, September 1970 47
2. Canadian Air and Precipitation Monitoring Network, September 1970 50
3. Pan American Air Sampling Program, September 1970, *PAHO* and *PHS* 51

Fallout in the United States and Other Areas, July–December 1968 and January–December 1969, *HASL* 52

Surface Air Sampling Program, 80th Meridian Network, January–December 1967, *HASL* 57

SECTION IV. OTHER DATA 67

Strontium-90 in Human Bone, January–March 1970 67

Environmental Levels of Radioactivity at Atomic Energy Commission Installations 70

1. Argonne National Laboratory, July–December 1969 70
2. National Reactor Testing Station, January–June 1969 77

Reported Nuclear Detonations, December 1970 80

Synopses iii

Guide for Authors .... Inside back cover

RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

Dr. Joseph A. Lieberman
Radiation Office

BOARD OF EDITORIAL ADVISORS

Dr. Harold O. Wyckoff — *Department of Defense*
Dr. Milton W. Lammering — *Environmental Protection Agency*
Dr. Maurice H. Frere — *Department of Agriculture*
Dr. Carl O. Muehlhause — *Department of Commerce*
Robert E. Simpson — *Department of Health, Education, and Welfare*
Dr. Martin B. Biles — *Atomic Energy Commission*

STAFF

Editor	Samuel Wieder
Managing Editor	Kurt L. Feldmann
Editorial Assistants	Jacqueline J. Copp Mary Needore
Illustrator	Marylee Hill

Address correspondence to the Editor, *Radiological Health Data and Reports*, *Radiation Office*, 1901 Chapman Avenue, Rockville, Md. 20852.

For subscriptions to *Radiological Health Data and Reports*, please use the order form on last page of this issue.

ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

Reports

Estimates of Potential Doses to Various Organs from X-radiation Emissions from Color Television Picture Tubes

Robert H. Neill, *Harry D. Youmans*, and *John L. Wyatt*[1]

Using the exposure rates determined in the metropolitan Washington color television survey, doses to various organs of children and adults were calculated. For a television receiver with a picture tube emitting 0.5 mR/h (the maximum exposure rate allowed under the Department of Health, Education, and Welfare performance standards) and with other specified assumptions, the calculated dose to a child ranged from 5 mrem/a (female gonads) to 42 mrem/a (skin). For an adult, the doses were 2 mrem/a to 18 mrem/a, respectively. Using the same assumptions but for a picture tube emitting 0.043 mR/h (the average exposure rate observed in the metropolitan Washington survey), the respective doses were 0.4 mrem/a to 3.6 mrem/a for a child and 0.2 mrem/a to 1.6 mrem/a for an adult.

This document presents estimates of organ doses that could result from color television receiver x-ray emissions under two operating conditions. The first condition of operation assumes that the picture tube emits 0.5 mR/h at 5 cm from the front face, which is the maximum allowable level under the Department of Health, Education, and Welfare (DHEW) performance standard (*1*). The second assumes that the front face of the picture tube emits x radiation at 0.043 mR/h, the average rate observed in the metropolitan Washington survey (*2*). Since all receivers emitting radiation in excess of the allowable level were corrected during the survey, the dose estimates represent the dose that would have occurred before correction. All calculations are based on the viewing habits indicated in the metropolitan Washington survey.

Types of exposure

While there are various ways that individuals can be exposed to x radiation emanating from color television receivers, two major types of exposure to people are:

1. picture tube face radiation (primarily a source of exposure to those watching television),
2. radiation from the shunt regulator tube, the rectifier tube, and other parts of the picture tube (possible sources of exposure to all persons in the room with the television receiver).

Dose estimates are presented only for the former case. None are presented for the latter due to lack of applicable data, since such estimates would involve the dose to an individual located at a specified distance from a television set operating for a specified length of time and emitting beams of specified directions, areas, and shapes.

Viewing population

While the Electronics Industries Association (EIA) has estimated that 95 percent of the approximately 60 million households in the United States have television receivers, only about 39 percent have color television (*3*). In view of the current production rate of 500,000 color television receivers per month and projections for the future, it is reasonable to presume that virtually the entire population will be color television viewers.

Although we give no consideration to multiple sources of exposure, it is interesting to note that the EIA estimates that 29 percent of the household in the United States now have more than one television receiver.

---

[1] Mr. Neill is director, Program Office; Mr. Youmans is physics advisor to the Director, Division of Biological Effects; and Mr. Wyatt is staff engineer, Intelligence Branch, Division of Electronic Products, Bureau of Radiological Health, Public Health Service, 5600 Fishers Lane, Rockville, Md. 20852.

Assumptions

The following assumptions are necessary to these calculations:

1. Hours per year that an individual spends viewing television

   On the basis of the metropolitan Washington survey, values of 1,100 hours per year (3 h/day) for children 14 years of age and under and 950 h/a (2.6 h/day) for people over 14 years old were selected as being typical (*2*). While these figures are similar to the 1,000 h/a used by Braestrup (*4*), they are somewhat lower than those recently reported by the A. C. Nielsen Company (*5*).

2. Distance from television receiver

   The limited data available on viewing distances from the Washington survey (*2*) indicate typical figures of 165 cm (approximately 5 feet, 5 inches) for children 14 and under and 250 cm (approximately 8 feet, 2 inches) for the remainder of the viewing population.

3. Reduction in intensity with distance

   The distance factor expresses the reduction in intensity as a function of distance from the screen. The reduction first begins to follow the inverse square law at a distance of about 75 cm, because the screen is not an isotropic point source. Data used in this report were taken from Wang (*6*) (figure 1) and represent the decrease in exposure rate along the central axis of a 25-inch, color television tube. No attempt has been made to take into account the fact that some people sit slightly to one side of the receiver.

   These data are presented in figure 1. Curves for exposure reduction at a 30° angle from the central axis of the 25-inch, black and white tube are presented for comparison. While it is recognized that many color television receivers have smaller picture tubes, the only available data are for the larger sizes. Radiation levels will, in general, fall off more rapidly with distance from a small screen receiver than from a larger one. The distance factors in x-ray intensity associated with viewing distances of 165 cm and 250 cm for children and adults were 0.070 and 0.036 cm.

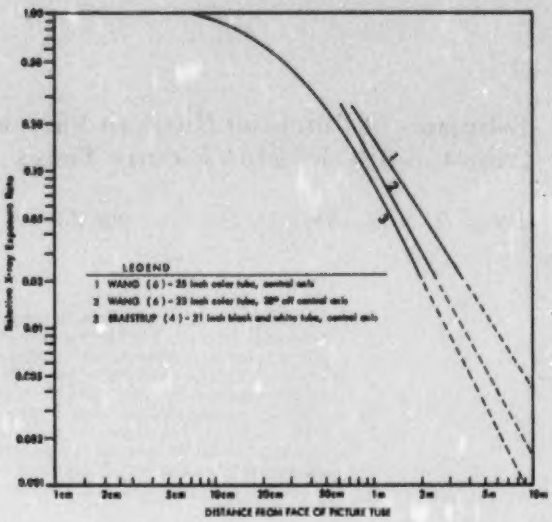


Figure 1. Reduction in x-ray intensity as a function of distance

4. Backscatter factor

   Radiation dosage in a sample of tissue results not only from photons traveling in the primary beam and impinging upon the sample, but also from photons and electrons scattered backward from tissue at a greater depth than the sample under consideration. The increase in dosage from this latter effect is represented by the tissue backscatter factor. In this report, a tissue-backscatter factor of 1.24 was used. This value applies to a 17.5 cm diameter beam with a half-value layer of 1.0 mm of aluminum (*7*).

5. Exposure-to-dose conversion factor

   The following conversion factor in muscle at 30 keV was used (*8*).

   $\bar{f} = 0.91$ rad/R

6. Organs and depth dose factors

   The organs considered are those discussed by Davis, Youmans, Wolff, and Mills (*9*). Bone marrow and central nervous system are not included because of attenuation afforded by bone, large volume, wide distribution in the body, and highly nonuniform dose distribution.

   Radiation dosage at a given depth in the body may be less than that at the surface of the skin because of the shielding afforded by intervening layers of tissue. This decrease in

5

radiation dosage with depth is represented by the depth dose factor.

The depth dose factors were taken from Mills (*10*) except where indicated. They are appropriate for use with any x-ray beam of spectral characteristics similar to those of radiations from television receivers (*11*). Values used were skin, 0.95; adult thyroids, 0.56; juvenile thyroids, 0.70 (an estimate based on the assumption of 8 mm depth below surface); male gonads, 0.41; female gonads, 0.11 (*4*); lens of eye, 0.80.

7. Quality factor

A quality factor of 1 mrem/mrad was used (*12*) throughout the calculations.

Computational method

The estimated average annual dose is computed as follows:

$$D = X\,T\,d\,B\,f\,F\,Q = 1.13\,X\,T\,d\,F$$

where

D = estimated average annual dose (mrem/a),
X = exposure rate at 5 cm from the front face of the picture tube (mR/h),
T = annual viewing time (h/a),
d = distance factor,
B = backscatter factor (1.24),
f = conversion factor (0.91 mrad/mR),
F = depth dose factor, and
Q = quality factor (1 mrem/mrad).

Discussion

Table 1 presents estimates of the annual dose to children and adults which could result if x-ray emissions from the front face of the picture tube are 0.5 mR/h, the maximum allowable under the DHEW performance standard.

The average front face exposure rate observed from the 1,124 color television receivers measured in the metropolitan Washington survey was 0.043 mR/h. The distribution is presented in figure 2.

Estimates of the average annual dose for both children and adults in households surveyed in the metropolitan Washington survey are shown in table 2. The difference is attributed primarily to differences in viewing habits of the two groups; children watch longer and sit closer than adults. The estimates are average doses which are based on average viewing habits and an average dose rate.

Table 1. Estimated average dose from the front face of picture tubes emitting 0.5 mR/h

Organ	Children less than 15 years of age (mrem/a)	People 15 years of age and older (mrem/a)
Skin	42	18
Thyroid	30	11
Male gonads	18	8
Female gonads	5	2
Lens of eye	34	15

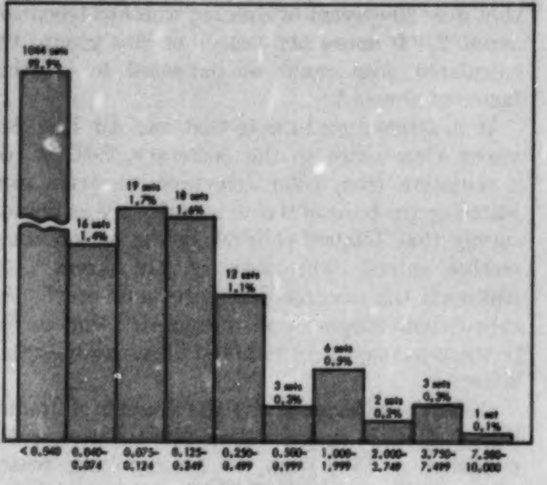


Figure 2. Front-face exposure rates observed from 1,124 color television receivers in the metropolitan Washington survey

While estimates of maximum doses are fraught with uncertainties due to the paucity of physical measurements and variability of viewing habits, we have attempted a semi-quantitative estimate as follows: about 1.33 percent (15/1,124) of the color television receivers measured in the metropolitan Washington survey emitted radiation from the front face of the picture tube at 0.5 mR/h or

Table 2. Estimated average dose from the front face of picture tubes emitting radiation at the average rate observed in the Washington metropolitan survey (0.043 mR/h)

Organ	Children less than 15 years of age (mrem/a)	People 15 years of age and older (mrem/a)
Skin	3.6	1.6
Thyroid	2.6	.9
Male gonads	1.5	.7
Female gonads	.4	.2
Lens of eye	3.0	1.3

more. The average dose rate for these 15 receivers was 2.7 mR/h. This would suggest that 1.33 percent of the viewing population might receive doses which are larger than those presented in table 2 by a factor of about 60 and about 5⅓ times the doses shown in table 1. Data collected during the survey indicate that 9 percent of the children viewed television at a distance of 4 feet or less. The dose estimates may be increased by a factor of about 2 for this group. These data also indicated that over 20 percent of children watched television about 2,000 hours per year. For this group, the calculated dose could be increased by another factor of almost 2.

It is interesting to note that the Ad Hoc Advisory Committee to the Secretary, DHEW, on x radiation from color television receivers estimated on the basis of the metropolitan Washington survey that 140,000 children in the nation could receive annual skin doses of 110 mrem (*13*). Although the average doses are quite small, the calculations suggest that a small fraction of the population may have received doses considerably larger.

Recent studies made by the Bureau of Radiological Health suggest that the emission rates published in 1968 from the Metropolitan Washington survey (*2*) may be high due to a lack of correction for energy dependence of the survey meters used. The appropriate correction factors, which are not presently available, may result in the published average emission rates being high by a factor of 1 to 2, and the maximum emission rates being high by a factor of 3. The average and maximum doses as reported herein, reflect those doses which would have occurred at the emission rates stated in the Washington survey report and under the assumed conditions.

Although only 1.33 percent of the receivers in the Washington, D.C., survey emitted 0.5 mR/h or more from the front face, 5.9 percent emitted 0.5 mR/h or more at some location 5 cm from the surface of the receiver. The Dade County Department of Health in Florida reported that, of 507 color receivers surveyed between 1967 and 1970, 9.1 percent emitted over 0.5 mR/h at some location.[4] In contrast, the Suffolk County Department of Health in New York in a revised statistical report on 5,429 color receivers surveyed between January 1968 and January 1970 obtained 16.2 percent for the percentage of receivers emitting over 0.5 mR/h at some point (*14*).

Due to the lack of applicable data, no allowance has been made for the fact that many people view the television screen from an angle or that children often lie on their stomachs to watch television while many adults prop their feet up on a stool. Viewing from an angle would cause a reduction in the dose to all organs (*6*), whereas lying face down or propping one's feet on a stool would tend to cause a reduction in gonadal dose.

For comparison purposes, the appropriate guidelines of the Federal Radiation Council (FRC) (*15, 16*) and the International Commission on Radiological Protection (ICRP) (*12, 17*) for limiting doses to the public are shown in table 3. The values shown are exclusive of doses from natural background and medical radiation exposure.

Table 3. Recommendations of the FRC and ICRP for limiting radiation exposure[a]

Organ	Individuals (mrem/a)	Populations (mrem/a)
Skin	3,000 (*12*)	
Thyroid	1,500 (*15*)	500 (*15*)
Gonads	500 (*12,16*)	[b]170 (*16*)
Lens of eye	1,500 (*15*)	

[a] These recommendations exclude occupational exposure, natural background and medical radiation exposure.
[b] Stated as 5 rem/30 years.

While the above guidance for populations is not directly comparable to the dosage estimates in this paper, it is included to indicate the relative magnitudes. The National Council on Radiation Protection and Measurements has recommended that students under 18 years of age not receive an additional exposure of more than 100 mrem/a as a result of educational activities. The average annual dose from natural background has been estimated to be between 90 and 200 mrem/a in most of the United States (*18*).

It is well recognized that such recommendations are based upon the number of individuals that may be exposed as well as the magnitude of exposure. Also, any exposure involves some degree of risk, and unnecessary exposure should be avoided regardless of amount. This is especially true in a time when the availability of products which produce radiation continues to increase and the knowledge of synergistic responses remains inadequate. There is evidence to indicate a general downward trend in radiation exposure rates from color television receivers since 1965. Figures 3 and 4, prepared from data published in the Washington survey, show this downward trend. The same trend can be noted in the results of surveys performed by the Dade County, Fla., Department of Public Health, from which figure 5 was taken. The decrease may be attributed to improved design, improved quality control procedures or increased awareness on the part of service repairmen of proper voltage settings or a combination of all three.

---

[4] Unpublished synopsis of the results of the Dade County surveys for 1967–1970, April 15, 1970.

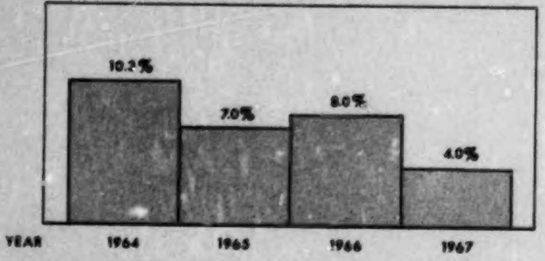


Figure 3. Percentage of color television receivers observed in the metropolitan Washington survey emitting 0.5 mR/h or more (classified by date of purchase)

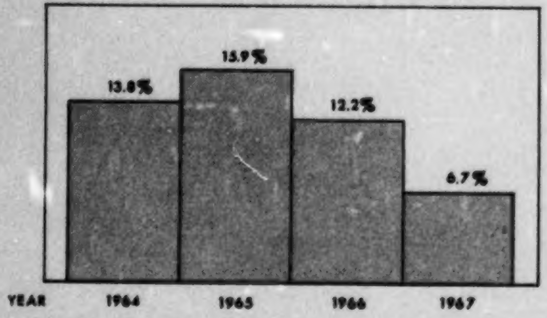


Figure 4. Percentage of color television receivers observed in the metropolitan Washington survey emitting 0.25 mR/h or more (classified by date of purchase)

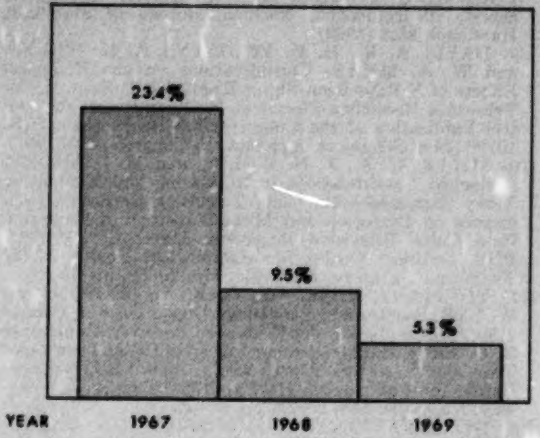


Figure 5. Percentage of receivers emitting 0.5 mR/h or more observed in the Dade County, Florida surveys (by year of survey)

REFERENCES

(1) DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, PUBLIC HEALTH SERVICE. Performance Standard for Television Receivers, Regulations for the Administration and Enforcement of the Radiation Control for Health and Safety Act of 1968. Federal Register 34:20259–20293 (December 25, 1969).

(2) NATIONAL CENTER FOR RADIOLOGICAL HEALTH, TECHNICAL SERVICES BRANCH. A summary of the Washington, D.C. metropolitan area survey of color television receivers. Radiol Health Data Rep 9:531–538 (October 1968).

(3) ELECTRONICS INDUSTRIES ASSOCIATION. 1969 Yearbook of the Electronics Industries Association, 2001 Eye Street, N.W., Washington, D.C.

(4) BRAESTRUP, C. B. and R. T. MOONEY. X-ray emission from television sets. Science 130:1071–1074 (October 23, 1959).

(5) THE A. C. NIELSEN COMPANY. Nielsen TV 69. The A. C. Nielsen Company, 2101 Howard Street, Chicago, Ill.

(6) WANG, S. P., S. SAVIC, and H. HERSH. Spectral and Spatial Distribution of X Rays from Color Television Receivers. Technical papers, Conference on Detection and Measurement of X Radiation from Color Television Receivers, March 28–29, 1968. PHS, National Center for Radiological Health, 12720 Twinbrook Parkway, Rockville, Md. 20852, pp. 53–72.

(7) HOSPITAL PHYSICS ASSOCIATION, BRITISH INSTITUTE OF RADIOLOGY. Depth dose tables for use in radiotherapy. British J Radiol, suppl 10:3 (figure 1.2.(1961).

(8) INTERNATIONAL COMMISSION ON RADIOLOGICAL UNITS AND MEASUREMENTS. Physical aspects of irradiation, National Bureau of Standards Handbook 85:3 (1962).

(9) DAVIS, A. K., H. D. YOUMANS, A. H. WOLFF, and W. A. MILLS. Considerations on the Biological Effects of X Rays from Shunt Regulator Tubes in Color Television Receivers. Electronic Products Radiation Control Publication of the Congressional Hearings on H.R. 10790 (First Session of the Ninetieth Congress, Fall 1967).

(10) MILLS, W. A., A. H. WOLFF, and M. L. SHORE. Biological Considerations in Measuring and Evaluating X-ray Exposures from Color Television Receivers. Conference on Detection and Measurement of X Radiation from Color Television Receivers, March 28–29, 1968. PHS, National Center for Radiological Health, 12720 Twinbrook Parkway, Rockville, Md. 20852, pp. 73–86.

(11) YOUMANS, H. D., JR., G. E. ANDERSON, and W. LEE. Spectra and Percentage Depth Dose of X Radiation Emitted by a Color Television Receiver. Conference on Detection and Measurement of X Radiation from Color Television Receivers, March 28–29, 1968. PHS, National Center for Radiological Health, 12720 Twinbrook Parkway, Rockville, Md. 20852, pp. 31–52.

(12) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendations of the International Commission on Radiological Protection, Report No. 9. Pergamon Press, New York, N.Y. (1965).

(13) U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE. Report of the Ad Hoc Advisory Committee to the Secretary, DHEW, on X Radiation from Color Television Receivers (August 6, 1968).

(14) BECKER, S. An investigation of x radiation from color television receivers in Suffolk County, New York. Radiol Health Data Rep 10:179–182 (April 1970).

(15) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

(16) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

(17) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 6 (as amended 1959, revised 1962). Pergamon Press, New York, N.Y. (1964).

(18) NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS. Radiation protection in educational institutions, Report No. 32. National Council on Radiation Protection and Measurements (July 1966).

Surveys of Radium Contamination in Aircraft Instrument Repair Facilities 1966–1967

Gail D. Schmidt,[1] *Jerome A. Halperin,*[2] *Eric Geiger,*[3] and *Walter Livingstone*[4]

A survey of 30 aircraft instrument repair facilities revealed many cases of significant radium contamination, resulting from repair and dial stripping operations on radium luminous dial instruments. Five out of 15 facilities surveyed in Wichita, Kans., showed alpha contamination exceeding 200,000 dpm/100 cm², with a maximum of 1,650,000 dpm/100 cm². The direct gamma radiation ranged from background to 60 mR/h. Whole body counts of 33 persons working in these facilities showed radium body burdens in two people that were about 40 percent of the maximum permissible body burden. A similar survey of 15 repair facilities in Dade County, Florida, showed lower alpha contamination levels by a factor of 10.

Based upon these findings, a radiation control program including contamination guides has been recommended for instrument repair facilities.

United States production of radium-226 has amounted to about 200 grams and about 1,800 grams have been imported (*1*). A substantial portion of this was utilized during World War II in radioactive self-luminous compounds for instruments, dials, and markers. Although production and use data are not available, estimates place the quantity of radium thus used at several hundred grams (*2*).

One major use of radium luminous compounds was to illuminate aircraft instruments (figure 1), particularly for military aircraft. Many of these instruments which were produced during and after World War II have been declared surplus by the military and are now being utilized by private industry (*2*).

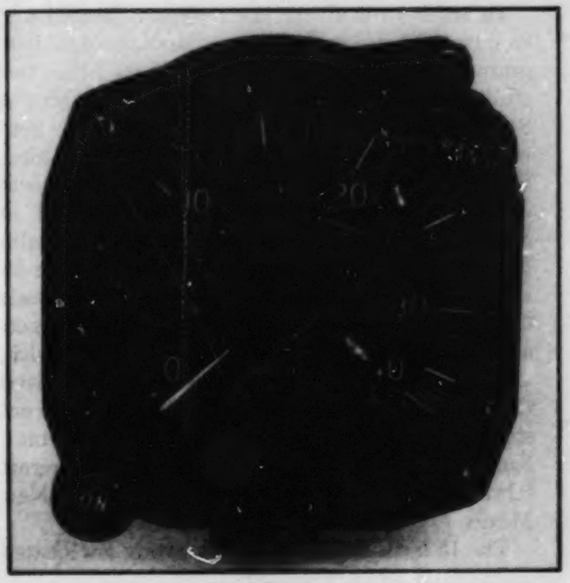


Figure 1. Radium dial instrument

---

[1] Mr. Schmidt is with the Bureau of Radiological Health, 5600 Fisher's Lane, Rockville, Md. 20852.

[2] Mr. Halperin is radiological health representative, EHS, Chicago, Ill. 60607.

[3] Mr. Geiger is with the Eberline Instrument Corporation, Santa Fe, N. Mex.

[4] Mr. Livingstone is with Dade County Department of Public Health, Miami, Fla.

To refurbish these instruments, the dials containing radium are removed, the old paint stripped from the dial, and the dial repainted. These tear down and dial stripping operations have produced significant contamination in the facilities where this type of work is done. These aircraft instruments containing radium are not labeled, and very few of the workers in these facilities are aware that a radiation hazard is involved. A study of luminising facilities in the United Kingdom has shown a correlation between facility contamination levels and radium body burdens of the workers (3).

Radium does not come under the regulatory authority of the Atomic Energy Commission and has only recently been regulated in those States where appropriate legislation exists.

Facilities which repair instruments for flight use must be certified by the Federal Aviation Agency (FAA) but no provision for radium control is included in the certification. The FAA has, however, recently issued a circular advising repair stations of the radiation hazard associated with the repair and maintenance of radium dial instruments (4).

Instrument repair and dial stripping operations

In order to evaluate the radiation hazard and to develop a recommended radiation control program for aircraft instrument repair facilities, two studies were conducted for the U.S. Public Health Service. The first study was conducted under contract[5] by the Eberline Instrument Corporation, Santa Fe, N. Mex., with the cooperation and assistance of the Kansas State Department of Health and the Wichita-Sedgwick County Health Department. The second study was conducted by the Florida State Board of Health and the Dade County Department of Public Health in cooperation with the Bureau of Radiological Health, U.S. Public Health Service. Each study involved the survey of 15 facilities. In the Eberline contract study, 14 facilities were located in the Wichita, Kans., area, which is primarily a light aircraft fabrication area and the 15th facility in New Mexico.

The 15 facilities in the Florida study are located in the Dade County, Fla., area and are primarily associated with providing service to commercial and private airlines.

The nature of the operations in these facilities can be broken down into the following areas:

Dial stripping and refinishing. After removal from the instrument, the dial faces are generally stripped. The first step involves soaking in a solvent, which contains halogenated hydrocarbons, chlorinated hydrocarbons, phenol and/or similar solvents. The dial face is then scrubbed with a brush to remove adhering deposits, rinsed in a detergent to remove oily deposits, and prepared for refinishing. The refinishing with nonradioactive paints is carried out with a silk screen stencil that is specific for a particular dial. Thus it is necessary for a facility to accumulate a large number of silk screens to match the many instrument types. In many cases, the old silk screens are contaminated with radium from former radium paintings and are a source of considerable contamination.

Instrument disassembly and repair. Instruments are disassembled in one area prior to transfer to a repair bench. The instrument disassembly area is another major source of contamination, since the radium paint is frequently chipped or cracked during this operation. Following repair, the instruments are tested and recalibrated.

Storage. Since there are many types and models of aircraft instruments and surplus sales generally involve a large group of instruments, most facilities have a large stock of used and surplus instruments and dials.

Other operations. Included in these surveys were several facilities, including distributors or manufacturers which did not currently work on radium dial instruments but had detectable contamination from past operations.

The 30 facilities in this study carried out the following operations on radium dial instruments.

Dial stripping and refinishing	10
Instrument disassembly and repair	21
Storage	approximately 25
Other	4

Twenty-two of these facilities were certified by the FAA (5). The distribution of these facilities by the FAA certification speciality of instrument, radio and accessory repair are shown in table 1 along with the total number of such certified stations in the United States (5). These repair specialties are not mutually exclusive since a given facility may be certified in several specialties. Those facilities surveyed but not FAA certified, include dial strippers and refinishers, distributors, and others which do no actual repair of flight instruments.

---

[5] Contract #PH-86-67-66.

Table 1. Facilities certified by the Federal Aviation Agency

Repair specialty	Total FAA certified stations	FAA certified stations in this study
Instrument	386	21
Radio	559	10
Accessory	496	10
Total facilities		22

Evaluation of radiation hazards

Surface contamination levels. The results of the field surveys of the 30 facilities involved are summarized in table 2. Total alpha contamination was determined using portable alpha survey meters (gas flow and alpha scintillation). These instruments were calibrated on each scale with standard plutonium alpha sources.

Significant amounts of removable long half-life alpha contamination were found in all cases where dial stripping was currently being performed or had been performed in the past. Lower levels of fixed and removable alpha contamination were found in instrument disassembly and storage areas. Dial refinishing areas showed some contamination which could be attributed to old silk screens and equipment that had been used in the past when dials were painted with radium luminous compounds.

Each facility will be described in terms of its maximum contamination since this parameter can readily be compared between facilities. The use of an average contamination value would be more appropriate; however, this is difficult to obtain where surveys have been conducted by different organizations, and a few high values can significantly affect the average, as will be shown later.

Figures 2, 3, and 4 show the distribution of facilities by maximum total and maximum removable alpha contamination on floors and benches.

Table 2. Contamination levels in aircraft instrument repair facilities[a]

Facility		Area	Maximum alpha contamination (dpm/100 cm²)	
Code	Type of operation		Total	Removable (long-lived)
Light aircraft fabrication area				
A	Stripping and repair	Benches	300,000	170
		Floors	100,000	270
B	Stripping and repair	Benches	167,000	2,100
		Floors	334,000	1,000
C	Stripping	Benches	[b]330,000	2,700
		Floors	[c]16,500	1,400
D	Stripping and repair	Benches	>330,000	500
		Floors	100,000	<300
E	Stripping and repair	Benches	16,700	190
		Floors	6,700	750
F	Stripping and repair	Benches	3,300	<100
		Floors	5,000	<100
Commercial aircraft area				
1	Stripping and repair	Benches	170,000	5,000
		Floors	4,700	1,850
2	Repair	Benches	136,000	300
		Floors	20,000	220
3	Repair	Benches	30,000	200
		Floors	68,000	780
4	Stripping and repair	Benches	34,000	350
		Floors	34,000	54
5	Stripping and repair	Benches	1,400	430
		Floors	2,700	24

[a] Of the facilities not specifically listed here, 12 had no contamination above background and the other 6 had only spotty contamination.
[b] Sink had a maximum value of 1,660,000 dpm/100 cm².
[c] Floor had been recently tiled, concrete under the tile may be more highly contaminated.

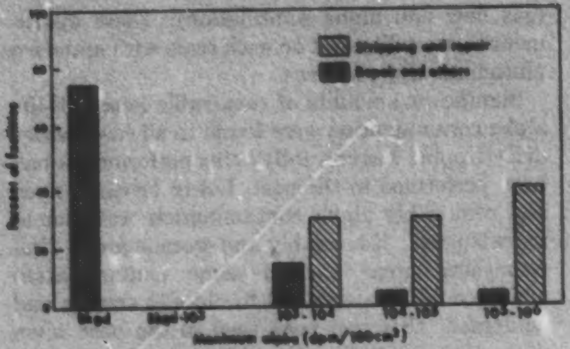


Figure 2. Distribution of facilities by maximum total alpha contamination on benches

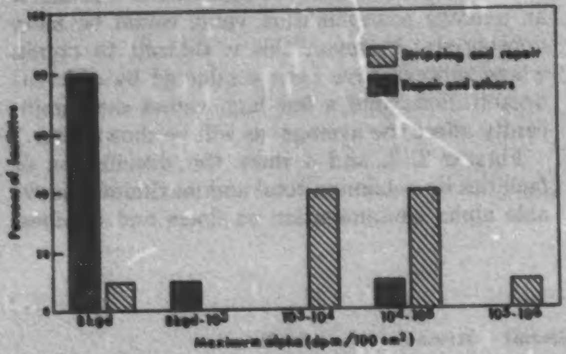


Figure 3. Distribution of facilities by maximum total alpha contamination on floors

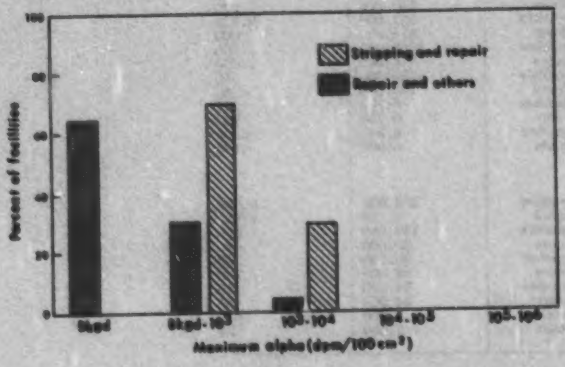


Figure 4. Distribution of facilities by total alpha removable contamination on floors and benches

It is observed that those facilities which performed dial stripping operations have significantly higher levels of contamination than those facilities which do not strip dials.

Radon air levels. Radon levels were measured by radon film badge (6) in the light aircraft facilities and by alpha counting of air filter samples for radon daughters (7) in the commercial airline facilities. Radon film badges worn for several months in facilities A, B, and H, generally indicated levels less than 30 pCi/liter with none exceeding 100 pCi/liter, the recommended occupational concentration guide for radon-222 in air (8). Radon film badges worn in facility C, where operations involved dial stripping and refinishing only, gave an average concentration of 370 pCi/liter (range, 40–1,400 pCi/liter) or almost four times the recommended occupational concentration guide in air. A large number of radium dials were stored and stripped in facility C, and this apparently accounts for the higher radon levels measured in this facility.

The radon levels in the commercial airline facilities did not exceed approximately $\frac{1}{10}$ of the recommended occupational concentration guide for air in either the storage or the work areas.

Airborne alpha levels. Long-lived alpha-particle concentrations in air were determined in facilities A, B, C, and H by filtration. The filters were counted with a large area, gas-flow proportional counter 5 days or more after collection so that only long half-life alpha-particle emitters were measured.

Table 3 summarizes the airborne concentrations of long half-life alpha-particle emitters for facility B, which was doing a large amount of disassembly work during the study, but no stripping of dials, and for facility C, which was doing a large amount of dial stripping work but no disassembly of

Table 3. Summary of long half-life alpha air concentrations—facilities B and C

Location	Number of samples	Average air concentration (pCi/m³)
Facility B		
Teardown area	9	1.18
Old stripping area	9	.09
Facility C		
Stripping area	13	2.5
Refinishing room	3	.50

instruments during the study. The concentrations were generally less than 10 percent of the recommended concentration guide of 30 pCi/m³ for occupational exposure to radium-226 (8).

Air samples from facility C indicated higher airborne concentrations of long half-life alpha emitters than in facility B, but in no case did the concentration approach the concentration guide. The maximum concentration measured was 7.4 pCi/m³ which is 25 percent of the concentration guide in air if it is assumed that all of the activity is radium-226 (no daughters present).

Air samples were collected in facility A and H over a period of several months. Concentrations of long half-life alpha emitters in these facilities were generally below 1 percent of the concentration guide for occupational exposure.

External hazards. Gamma radiation levels above 2 mR/h were frequently observed. However, these were generally in storage areas, and radiation levels in work areas were localized or the area had a limited occupancy time. The storage area was usually a drawer or box where dial faces were stored or shelves where complete instruments were stored. Radiation levels to which a significant portion of the body could be exposed were generally 5 mR/h or less with one exception; a desk drawer containing a large number of dials gave a reading of 13 mR/h at 30 cm (1 foot) from the top of the drawer.

Significant levels of gamma radiation were also present in areas where paint and residues from the dial stripping operation had accumulated. The distribution of the facilities by maximum gamma levels and work area gamma levels are shown in figures 5 and 6, respectively. Again it is observed that radiation levels are generally greatest in those facilities that strip dials.

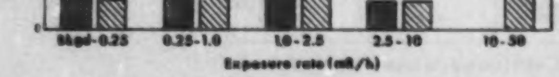


Figure 5. Distribution of facilities by maximum gamma radiation

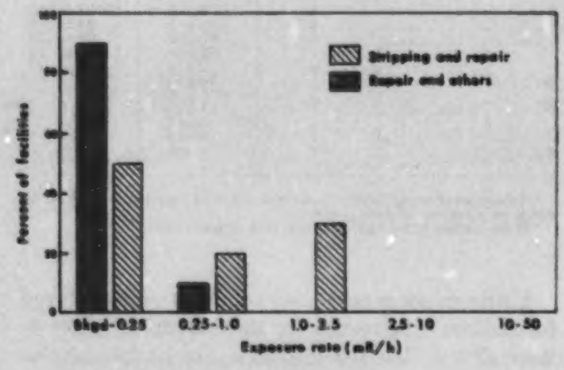


Figure 6. Distribution of facilities by work area gamma levels

Beta-gamma film badges were worn for 2 months in facilities A, B, and C, with biweekly exchange. Beta-gamma film badges were worn in facility H for 6 months with monthly exchange. All of these badges showed exposures of less than 10 mR gamma and less than 10 mrad beta exposure (the minimum detectable level for the film badge).

Internal hazards. The mobile whole body counting facility of Helgeson Nuclear Services, Inc., was used to determine the radium content of selected workers from each participating company in the light aircraft fabrication area. The detector was a 20 cm (8 in.) diameter by 10 cm (4 in.) thick NaI(Tl) crystal with a cesium-137 resolution of 7.6 percent. A shadow shield was used to reduce the background.

The whole-body counter was located at the Wichita-Sedgwick County Health Department on July 5, 6, and 7, 1967, and employees of the participating companies were scheduled to report there for counting. Two individuals who had not worked with radium were counted as controls. After showering carefully and putting on a clean pair of coveralls, all persons were counted for 20 minutes. The body burden calculation was based on a 30-percent retention of the radon gas from radium in the body (9) and the 1.76 MeV gamma of bismuth-214. Only data for the two persons from facility C (a dial stripping operation), whose body burdens were 41 and 43 nCi of radium, are considered significant (table 4).

Table 4. Radium-226 body burden assessments

Facility	Number of individuals	Whole body count [a](nCi)	Urinalysis (pCi/24 h)
A	4	≤ 9± 9	≤0.08±0.12
B	4	≤ 7± 8	≤ .06± .08
C	1	41±10	.66± .20
	1	43±10	.22± .12
	1	6± 9	.16± .10
D	1	10±10	
	5	≤ 5± 8	
E	1	14±10	
	1	10±10	
	7	≤ 6±10	
6	1	[b]2±11	

[a] Values listed are individual body burdens or the maximum value when given for a number of individuals.
[b] Body burden based upon radon breath measurement.

Urine samples were also collected and analyzed for radium. The results for these samples (table 4) were all less than 0.2 pCi/24 h, except for samples from the two individuals at facility C who had significant body burdens. The radioactive material in these urine samples was positively identified as radium-226 by alpha spectrometry.

One individual in the "commercial airline area" was assessed for radium body burden by radon breath sampling. The results were negative as shown in table 4. This individual has worked in instrument repair and dial painting for 25 years and repairs watches and paints hands and faces with radium luminous compounds in his home workshop.

Contamination study. In order to thoroughly evaluate the radiation hazards involved, a detailed survey was made of the contamination levels in facilities A, B, and C. Table 5 summarizes the total alpha contamination of these facilities (the data in table 5 is from a survey in June 1967 and differs slightly from the data in table 2 which includes data from the initial survey in December 1966). The average gross alpha contamination level of 50,000 dpm/100 cm² for facility C is a factor of six higher than A or B. If the maximum value of 1,650,000 dpm/100 cm² is not included in the average, the difference is only a factor of about 2.4.

Since these averages appeared subject to considerable fluctuation, the "area integral" was calculated as an attempt to derive a more meaningful measure of facility contamination. The surface contamination measurements were plotted on a facility floor plan and isopleths defining areas of essentially equal contamination were drawn. The "area integral" contamination value is then the summation over the facility floor area of the contamination levels times the fractional area involved. The "area integral" value of 4,100 dpm/100 cm² for facility C is twice that of facility A or B. Graphically, facility C appeared more highly contaminated with general levels of about 1,000 dpm/100 cm², whereas facilities A and B had general levels of about 50–200 dpm/100 cm². The "area integral" values noted above (table 5) result primarily from the limited areas of high contamination in the stripping and disassembly area.

It was expected at the onset of these studies that the data might help answer the question—what is an acceptable contamination level? As noted above, only facility C had individuals with positive radium body burdens. Thus, the conclusions that can be drawn with regard to a relation between contamination and internal radiation hazard is rather limited. The negative data do, however, allow one to draw the general conclusion that work under these conditions has not

Table 5. Total alpha contamination characteristics of facilities A, B, and C[a]

Contamination characteristic	Total alpha[b] (dpm/100 cm²)		
	A	B	C
Maximum	100,000	82,000	1,650,000
Gross average	8,300(67)	7,900(67)	50,000(53) [c]47,000(20)
Average of values > 3,000	53,400(10)	20,600(25)	123,000(21)
Average of values ≤ 3,000	450(57)	310(42)	1,600(32)
Area integral[d]	2,300	1,800	4,100

[a] The data here are from a survey in June 19, 1967, while the data in table 1 include a December 1966 survey.
[b] Value in parenthesis is the number of survey readings.
[c] Average value with the maximum level excluded.
[d] The area integral was determined by drawing contamination contours on the facility floor plan and summing the product of contamination level times fractional area.

15

resulted in internal exposure exceeding the maximum permissible body burden.

Facility C, which had personnel with detectable radium body burdens, also had the highest levels of contamination. These individuals had painted with radium luminous compounds in the past and thus the source of internal body burden is uncertain. However, it appears that alpha contamination levels exceeding 200,000 dpm/100 cm^2 total-maximum and 50,000 dpm/100 cm^2 total-average are unsatisfactory and may lead to unnecessary body burdens. Therefore, it appears appropriate to arbitrarily take $\frac{1}{10}$ of these alpha values or

25,000 dpm/100 cm^2 total-maximum
5,000 dpm/100 cm^2 total-average
500 dpm/100 cm^2 removable-average
(comparable value)

to be acceptable contamination guides.

These levels are more conservative than those recommended by Duggan and Godfrey (*4*) and comparable to those recommended by Schmidt (*10*). The Kansas State Department of Health has adopted "working levels of contamination in any aircraft instrument repair facility" of 10,000 dpm/100 cm^2 maximum alpha, 2,500 dpm/100 cm^2 average alpha and 500 dpm/100 cm^2 of removable alpha. It is felt that the levels recommended here are attainable and appear to be appropriate for contamination control purposes.

The "area integral" contamination level, as derived above, may be expected to show a better correlation with internal exposure than maximum and average values. A recommended "area integral" limit has not been made because of the experimental nature of this concept and our limited experience in using this parameter.

Industry limitations

The aircraft instrument repair facilities surveyed have not shown the ability to decontaminate their facilities and establish effective control programs. An initial survey by the Kansas State Department of Health revealed extensive levels of contamination, and the facilities were directed to decontaminate and to initiate adequate radiation control programs. The survey 6 months later indicated no significant decrease in contamination levels. Most of the facilities surveyed had no instrumentation for detection of radiation. Only two had any alpha instrumentation, and only three had beta-gamma instruments.

In general, personnel working in these facilities have not received even basic training in radiological safety or contamination control.

The disposal of waste from the dial stripping operation is also a problem. Until recently, the waste was burned in a hood, dumped on the ground outside, released to the sewer, or retained in a hold tank and subsequently taken to the sewage treatment plant. Personnel at these facilities are not familiar with the Department of Transportation regulations pertaining to shipment of radioactive waste. Most facilities need assistance in packaging, monitoring, labeling, and disposing of their radium waste.

Both surveys revealed that radium or radioactive luminous paint was not being currently used to refinish aircraft instrument dials (except for infrequent individual requests). The problems of contamination are thus associated only with the surplus dials which are being reconditioned and existing dials on operating aircraft. The survey in the Miami area indicated that none of the commercial airlines serving that area are now using radioactive luminous dials and that most airlines had ceased this practice several years ago. The dials are now being repainted with fluorescent and phosphorescent finishes and similar compounds which are activated by ultraviolet or black light and contain nonradioactive materials. Matte white is also used as a nonluminous finish.

Moreover, the problem may be a diminishing one in that most of the instruments that are worth rehabilitating have already had the radium dial replaced with a non-radium dial. Approximately 5 percent of the aircraft instruments in facilities A and C contained radium dials. In many cases, the dial stripping operation can be eliminated entirely without any serious economic impact. However, these facilities are still faced with the problem of decontamination of their facility. In some cases, they can accomplish this decontamination within their own capabilities, provided they obtain suitable instrumentation.

Conclusions

1. Aircraft instrument repair facilities should obtain radiation protection services on a consultant basis if such competence is not available within the company. Such services should be considered mandatory for facilities that strip surplus radioactive dials.

2. Total alpha contamination in aircraft instrument repair facilities should be restricted to levels less than 25,000 dpm/100 cm^2 maximum total 5,000 dpm/100 cm^2 average total and 500 dpm/100 cm^2 removable.

Surface contamination limits should be applied with professional judgment and used only as guides for indicating good housekeeping and general adequacy of the radiation control program. Compliance with contamination guides should not be used as evidence that exposure of persons to internal sources of radiation is within the prescribed standards. Biological sampling or whole body counting should be used to ascertain that the internal exposures are acceptable. It is recommended that contamination levels, especially removable activity, be kept as low as practicable.

3. Dial faces containing radium and aircraft instruments containing radium dials should be segregated using a beta-gamma survey meter from those that do not contain radium. Visual segregation of radium luminous dials is not accurate nor acceptable.

4. The stripping of dials containing radium paint should be discontinued in all facilities where suitable alternatives can be found. If dial stripping must be continued, the procedure recommended by Geiger (*11*) should be used.

5. Instrument disassembly should be done on a plastic sheet or bench paper which can be rolled up and discarded when it becomes contaminated.

6. Urinalysis should initially be done monthly on persons engaged in dial stripping operations involving radioactive material. If three consecutive monthly samples are negative, the collection frequency may be reduced to not less than once every year. If urinalysis provides a positive indication of radium in the body and this result is confirmed by a resample, the person should be whole body counted.

7. Air samples should be collected in areas where instruments are stored, disassembled, or dials are stripped, unless data over a period of several weeks indicate that concentrations in these areas are unlikely to exceed 10 percent of the maximum permissible concentration for occupational exposure.

8. Radium waste should be confined to as small a volume as practical. This waste should be packaged in plastic-lined metal drums. Liquid waste should be evaporated or packed with sufficient absorbent so that all the liquid would be absorbed if the primary container should leak. If an area within the State has been approved by the appropriate regulatory agency for disposal of radium waste, this facility should be used. If such a facility is not available within the State, a commercial waste disposal service should be encouraged to establish a collection and temporary storage facility within the State and provide assistance to each facility to assure compliance with the packaging, labeling, and shipping requirements of the Department of Transportation.

9. Other State or local radiological health agencies having aircraft instrument repair facilities should initiate surveys to determine the extent of radiation contamination and personnel exposure.

10. State radiological health agencies may also wish to consider conducting or sponsoring training programs in radiation protection for persons working in aircraft instrument repair facilities.

REFERENCES

(*1*) SCOTT, W. and J. VILLFORTH. Radium usage, control still medical problem. Your Radiologist 8:13–23 (1965).

(*2*) HALPERIN, J. and J. M. HESLEP. Radium in military surplus commodities. Public Health Rep 81:1057–1063 (1966).

(*3*) DUGGAN, M. and B. GODFREY. Some factors contributing to the internal radiation hazard in the radium luminising industry. Health Physics 13:613–623 (June 1967).

(*4*) FEDERAL AVIATION ADMINISTRATION. Hazards of radium-activated luminous compounds used on aircraft instruments. Federal Aviation Administration Advisory Circular AC No. 20-64 (November 24, 1967).

(*5*) FEDERAL AVIATION ADMINISTRATION. Consolidated listing of FAA certified repair stations. Federal Aviation Administration Advisory Circular AC No:140-1C (July 1, 1967).

(*6*) GEIGER, E. Radon film badge. Health Phys 13:407–411 (April 1967).

(*7*) HOLADAY, D., D. RUSHING, R. COLEMAN, P. WOLLRICH, H. KUSNETZ, and W. BALE. Control of radon and daughters in uranium mines and calculations on biologic effects, PHS Publication No. 494. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (1957).

(*8*) Code of Federal Regulations, Title 10 (Atomic Energy Commission), Part 20, Standards for Protection Against Radiation.

(*9*) NORRIS, W., T. SPECKMAN, and P. GUSTAFSON. Studies of metabolism of radium in man. Amer J Roentgenol 73:785–802 (1955).

(*10*) SCHMIDT, G. D. Survey of Radioactive Surface Contamination Guides. Presented at American Public Health Association, Miami Beach, Fla., October 23–27, 1967.

(*11*) BUREAU OF RADIOLOGICAL HEALTH. Evaluation of Radium Contamination in Aircraft Instrument Repair Facilities. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1969).

Environmental Survey of Uranium Mill Tailings Pile, Mexican Hat, Utah

Robert N. Snelling[1]

At the request of the Navajo Tribal Council through the PHS Division of Indian Health at Window Rock, Ariz., an environmental radiological survey was conducted on the A–Z Minerals Corporation uranium tailings pile, Mexican Hat, Utah, in May 1968. The purpose of the survey was to identify any radiation hazards which might exist and recommend methods for their control. The survey included evaluation of external gamma radiation and airborne and waterborne radioactivity.

The results of the survey indicate that the external radiation levels on the tailings area exceed recommended exposure limits for individuals in the general population. Therefore, the area should not be released for public use in its present state. Action which would permit the release of the area would involve covering the tailings with uncontaminated soil to an extent that would diminish the external radiation to an acceptable level and to stabilize the covering against wind erosion.

Radiation levels in air and water do not exceed recommended exposure limits. However, to minimize the possibility of increased activity from weather conditions different from those existing during the survey, it is recommended that the tailings be stabilized against wind erosion or periodic monitoring will be necessary.

At the request of the Director, Division of Indian Health, the Bureau of Radiological Health conducted a study of the A-Z Minerals Corporation's tailings pile located at Mexican Hat, Utah. It was requested that the study identify any radiation hazards which might exist and recommend methods for their control. In response to this request, the tailings area was surveyed in May 1968.

The mill was originally operated by the Texas-Zinc Minerals Corporation and transferred to A-Z Minerals Corporation in 1963. Uranium production was discontinued in February 1965. The mill property is located approximately 1 mile southwest of the community of Mexican Hat, Utah (figure 1). The site is situated on the Navajo Indian Reservation and is leased to the company by the Navajo Tribal Council.

The San Juan River flows from east to west approximately 1 mile north of the mill property. Gypsum Creek (actually a dry wash) is located approximately ½ mile east of the tailings pile. The surrounding land is unpopulated and at present is not used for either farming or grazing.

The mill property is divided into three main areas: the tailings area, the mill area, and the housing area (figure 2). The tailings area covers approximately 35 acres and contains an estimated 2.2×10^6 tons of tailings material.[2] The radium content, estimated from the average uranium assay of mill feed material (assuming radium in equilibrium with uranium), is approximately 1,000 pCi/g, or 2,000 total curies.[2] The mill area includes the mill buildings and former stock pile areas. It is located adjacent to and west of the tailings area. The housing area is located approximately 0.5 miles southwest of the tailings area and consists of approximately 60 dwellings, a school, and various community buildings.

Sampling procedures

External radiation measurements were obtained using portable Geiger survey meters. Gamma (closed window) readings were obtained at the surface and at the 3-foot level. A grid was es-

---

[1] Mr. Snelling is with the Technical Services Program, Southwestern Radiological Health Laboratory, Bureau of Radiological Health, Las Vegas, Nev.

[2] Division of Raw Materials, USAEC, 1967.

19

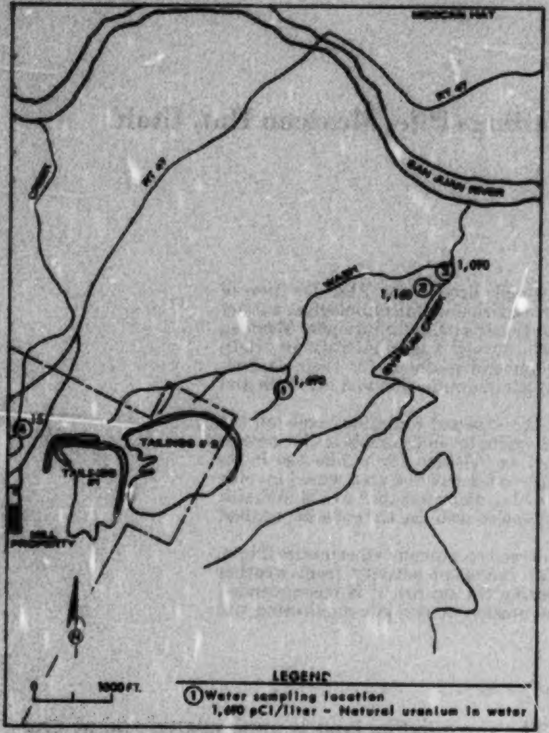


Figure 1. Water sampling locations with natural uranium concentrations Mexican Hat uranium mill, Utah

tablished over the area of interest and readings obtained at 240-foot intervals. A total of 212 pairs of readings was recorded.

In addition to the portable instrument readings, thermoluminescent dosimeters (TLD) were placed in triplicate at the 3-foot level at each of the air sampling stations (figure 3). The TLD's respond only to gamma radiation.

Long-lived airborne particulate radioactivity was sampled by drawing air through a 0.8μ pore size filter. A high-volume air sampler was used at a flow rate of about 5-cubic feet per minute. Nine sampling stations were established on and about the tailings area (figure 2). Continuous 24-hour samples were obtained at each station on each of 11 consecutive days. Each individual filter was analyzed for gross alpha radioactivity. In addition, all filters from each station were composited for analysis of natural uranium, radium-226, and thorium-230.

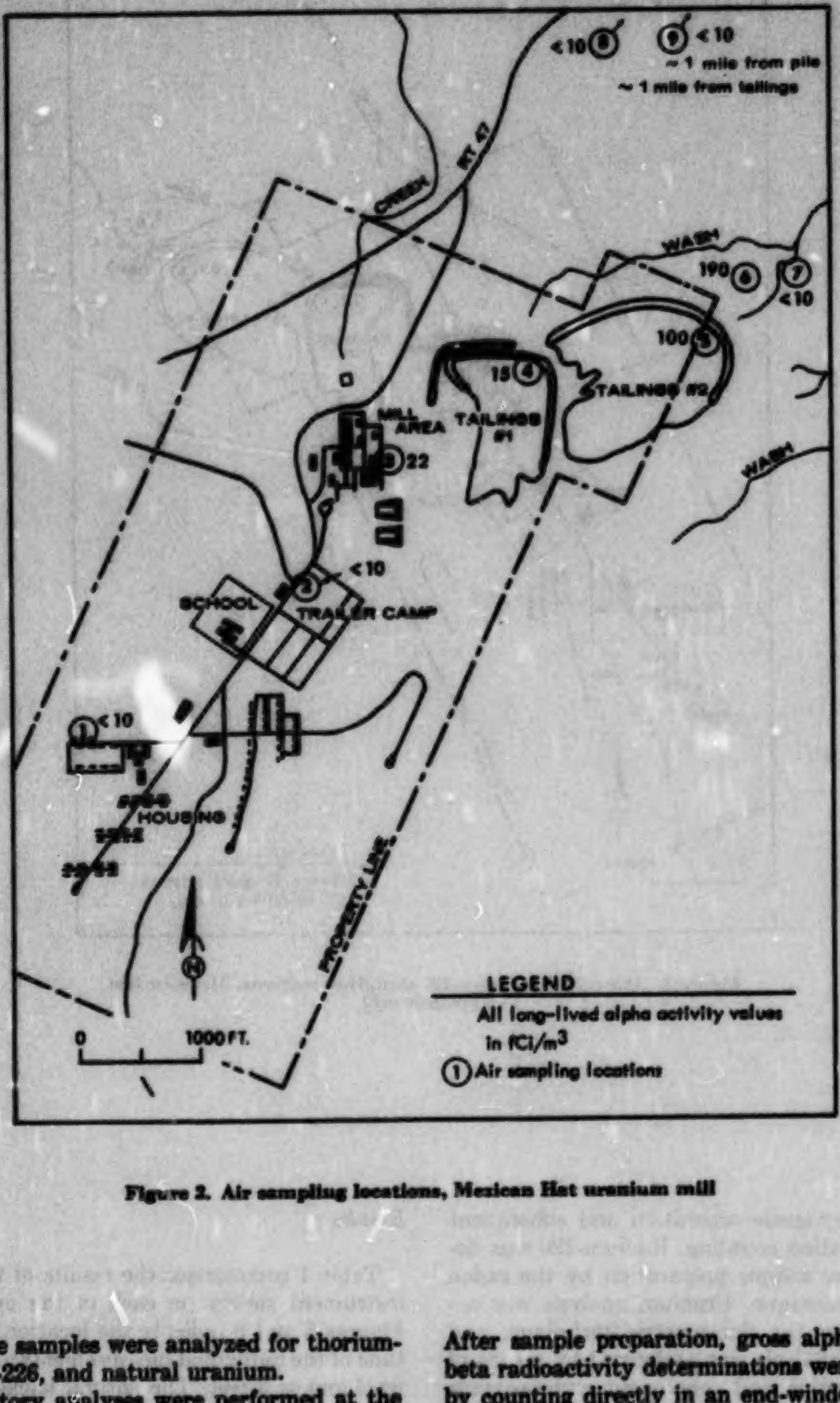
Eight locations were selected for the collection of radon gas samples (figure 3). The sampling technique consisted of pulling filtered air through a small low-volume pump (10 ml/min) into a 30-liter Mylar bag (*1*). A continuous 24-hour sample was collected at each location. The collected samples were picked up by Public Health Service aircraft and flown to Las Vegas for immediate analysis for radon-222.

The short-lived particulate radon daughter products were sampled by pulling air through a glass-fiber filter using a high-volume air sampler. Each sample was collected for 15 minutes at a flow rate of about 10 cfm. Samples were collected at the radon sampling locations (figure 4). The filters were counted for alpha radioactivity immediately in the field utilizing a specially designed alpha scintillation counter. Activity was calculated using the Tsivoglou technique (*2*).

Wind direction and speed were estimated by visual observation. The predominant wind direction at the mill site for the 11-day sampling period was from the southwest. According to A-Z Minerals Corporation personnel, this is the predominant wind direction throughout the year. During the first 7 days of sampling, the wind was light (0–5 mph). During the last 4 days, however, winds estimated at 10–20 mph were encountered during the daylight hours. In general, lapse conditions were encountered during daylight hours with light inversions at night.

Two springs were located in the vicinity of the tailings area at which ground water samples were taken (figure 1). The first was located about 1,000 feet northeast of the tailings area in the wash running from the tailings area (station 1). The wash was dry between the spring and Gypsum Creek. The second spring was just south of the junction of Gypsum Creek and the wash from the tailings area (stations 2 and 3). Gypsum Creek was dry upstream from the spring. In addition to the ground water samples, the drainage from the acid blowdown operation at the mill was sampled (station 4). One-gallon grab samples were obtained at each location, some stations being sampled on several occasions. The samples were analyzed for radium-226 and natural uranium activity.

Samples of tailings material were collected at the locations indicated in figure 4. Approximately 400 cm^3 of surface material was taken from each



<10 ⑧
⑨ <10
~ 1 mile from pile
~ 1 mile from tailings
CREEK
RT. 47
WASH
190 ⑥
⑦ <10
100 ⑤
15 ④
TAILINGS #2
TAILINGS #1
MILL AREA
8
③ 22
② <10
SCHOOL
TRAILER CAMP
① <10
HOUSING
PROPERTY LINE
N
WASH
0
1000 FT.
LEGEND
All long-lived alpha activity values in fCi/m³
① Air sampling locations

Figure 2. Air sampling locations, Mexican Hat uranium mill

location. The samples were analyzed for thorium-230, radium-226, and natural uranium.

All laboratory analyses were performed at the Southwestern Radiological Health Laboratory.

After sample preparation, gross alpha and gross beta radioactivity determinations were performed by counting directly in an end-window gas flow, proportional counter. Radon analysis was per-

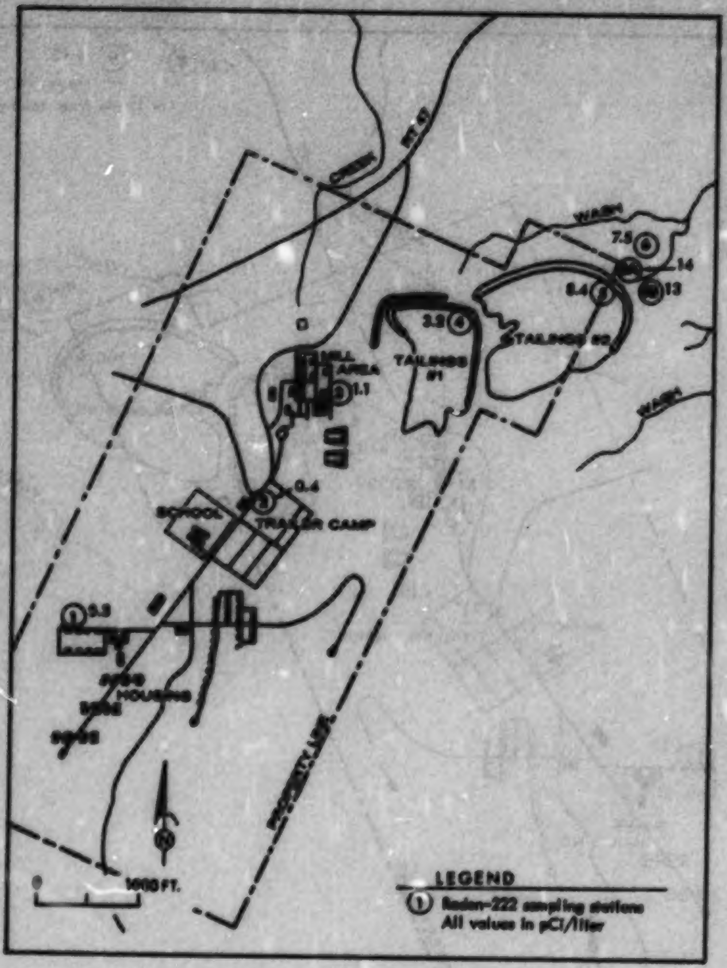

RT. 47
CREEK
WASH
7.5
14
8.4
13
3.2
TAILINGS #1
TAILINGS #2
MILL AREA
1.1
0.4
SCHOOL
TRAILER CAMP
3.3
HOUSING
PROPERTY LINE
N
0
1000 FT.
LEGEND
Radon-222 sampling stations
All values in pCi/liter
WASH

Figure 3. Atmospheric radon-222 sampling stations, Mexican Hat uranium mill

formed by cryogenic separation and subsequent alpha scintillation counting. Radium-226 was determined after sample preparation by the radon emanation technique. Uranium analysis was accomplished by the fluorometric technique, and thorium-230 analysis was performed by means of solvent extraction and subsequent alpha-particle counting.

Results

Table 1 summarizes the results of the portable instrument survey on each of the unique areas. Figures 5 and 6 indicate the location and magnitude of the individual measurements at the surface level and at 3 feet. The natural background radiation was found to average 0.03 mR/h both at

22

Table 1. External radiation measurements, Mexican Hat uranium mill, May 1968

Area	Number of measurements	Radiation levels at surface (mR/h)		Radiation levels at 3 feet (mR/h)	
		Average	Range	Average	Range
Background	10	0.02	0.02–0.06	0.03	0.02–0.06
Housing	74	.04	.01– .2	.03	.01– .1
Mill	21	.17	.02– .5	.15	.02– .5
Tailings	97	.5	.01–3.0	.5	.02–3.0

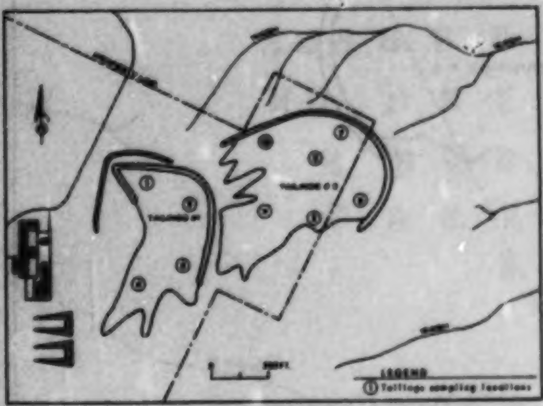


Figure 4. Tailings material sampling locations Mexican Hat uranium mill

Table 2. Comparison of TLD and Geiger meter data May 1968

Station	Exposure at 3 feet (mR/h)	
	TLD[a]	Geiger meter[b]
1	0.01	0.03
2	.03	.06
3	.06	.06
4	.55	.50
5	.42	.40
6	.04	.05
7	.03	.03
8	.01	.02
9	.02	.03
Background 1	.01	.02
Background 2	.01	.03

[a] Eleven day exposure period.
[b] Single survey meter reading.

the surface and the 3-foot level. The radiation exposure at the 3-foot level on the tailings area ranged from a minimum of 0.02 mR/h on the extremities of the pile to a maximum of 3 mR/h on the pile. The average was 0.5 mR/h. No significant difference was noted between the surface and 3-foot level. The average exposure at the 3-foot level within the mill area was 0.15 mR/h with a range of 0.02 to 0.5 mR/h. Again, there was no significant difference between readings at the surface and at 3 feet. The average exposure at the 3-foot level in the housing area was found to average 0.03 mR/h. This exposure represents background radiation. A comparison of the results obtained from the TLD's and the portable instrument measurements is shown in table 2. The results are in good agreement.

Table 3. Gross alpha radioactivity in airborne particulates, Mexican Hat uranium mill

Station number	Gross alpha radioactivity (fCi/m³)											
	May 1968				June 1968							
	28	29	30	31	1	2	3	4	5	6	7	Average
1	12	[a] <10	<10	<10	<10	<10	<10	<10	10	<10	<10	<10
2	19	<10	<10	<10	<10	<10	<10	27	<10	<10	30	<10
3	28	11	15	19	14	22	10	57	40	40	19	22
4	NS	<10	9	41	12	<10	15	<10	10	20	61	15
5	270	NS	NS	78	100	46	NS	270	NS	51	66	100
6	<10	15	84	340	36	24	48	380	510	230	370	190
7	<10	<10	<10	24	<10	NS	NS	NS	NS	NS	NS	<10
8	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
9	<10	<10	<10	<10	<10	<10	<10	<10	12	11	12	<10

[a] Assumed equal to zero for averaging.
NS, no sample.

23

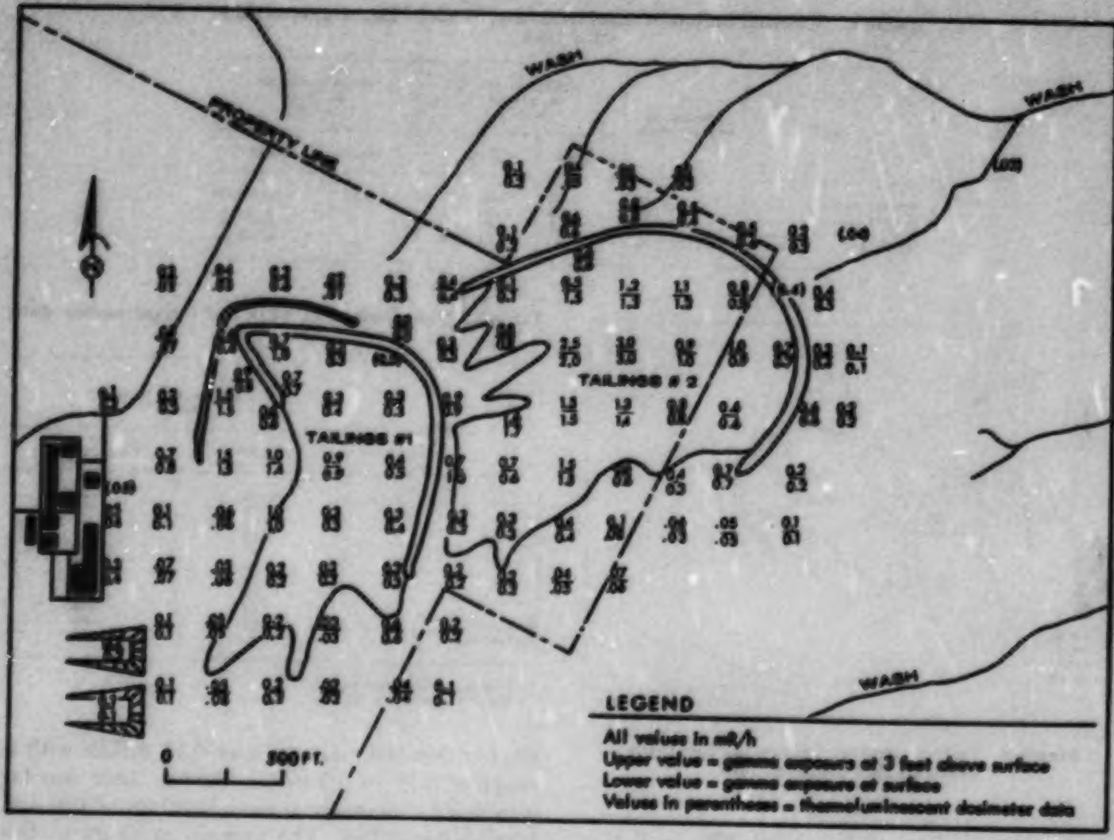

WASH
WASH
PROPERTY LINE
TAILINGS #1
TAILINGS # 2
WASH
0
500 FT.
LEGEND
All values in mR/h
Upper value = gamma exposure at 3 feet above surface
Lower value = gamma exposure at surface
Values in parentheses = thermoluminescent dosimeter data

Figure 5. External radiation measurements, Mexican Hat uranium mill tailings piles

The gross alpha radioactivity found on individual filters is shown in table 3. The background station (station 1) averaged less than 10 fCi/m^3 for 11 days of sampling. Stations 2, 7, 8, and 9 also averaged less than 10 fCi/m^3 indicating background levels of radioactivity. Stations 3 and 4 averaged slightly above background (station 3, 22 fCi/m^3; station 4, 15 fCi/m^3). Stations 5 and 6 were significantly above background levels. Station 5, located on the northeast edge of the tailings pile, averaged 100 fCi/m^3 with a range of 46 to 270 fCi/m^3 for 7 days of sampling. Station 6, located approximately 500 feet northeast from the tailings, averaged 190 fCi/m^3 with a range from less than 10 fCi/m^3 to 510 fCi/m^3 for 11 days of sampling. The average station results are shown in figure 9. It is apparent that the activity concentrations are higher than background in the vicinity of the tailings pile and that the values downwind from the tailings are higher than those upwind.

Table 4 shows the average gross alpha radioactivity along with radium-226, thorium-230, and natural uranium activity for each station. It should be noted that stations 3–6 (those indicating positive gross alpha radioactivity results) display radium concentrations averaging about a factor of ten higher than the other stations. These same stations show significant concentrations of thorium-230, whereas all other stations do not. Although the natural uranium concentrations average slightly higher for stations 3–6, the increase does not appear to be significant with the exception of station 3.

24

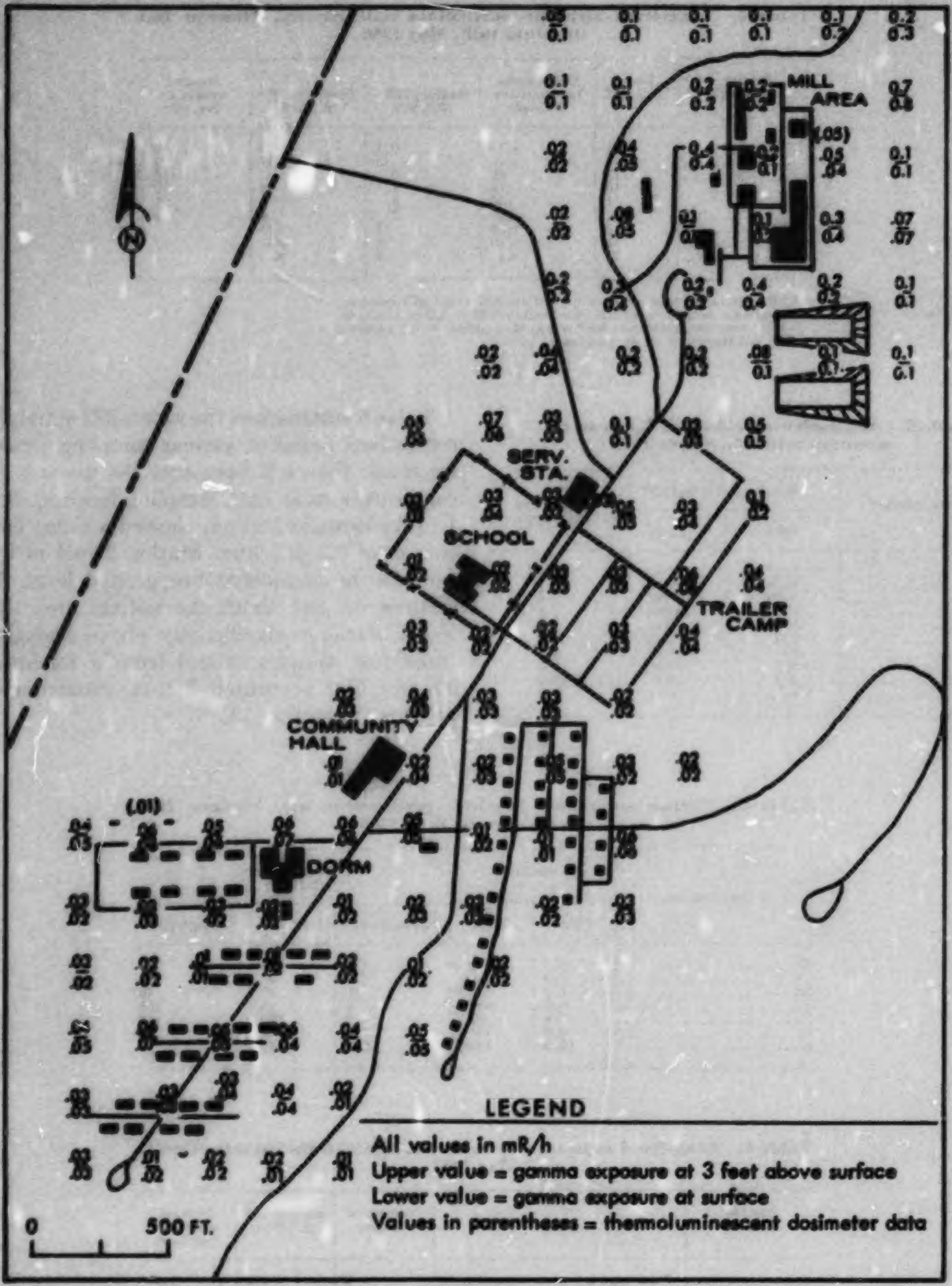

N
MILL
AREA
(.05)
SERV.
STA.
SCHOOL
TRAILER
CAMP
COMMUNITY
HALL
(.01)
DORM
LEGEND
All values in mR/h
Upper value = gamma exposure at 3 feet above surface
Lower value = gamma exposure at surface
Values in parentheses = thermoluminescent dosimeter data
0
500 FT.

Figure 6. External radiation measurements, Mexican Hat uranium mill

Table 4. Long-lived airborne particulate radioactivity, Mexican Hat uranium mill, May 1968

Station number	Days sampled	Gross alpha radioactivity (fCi/m³)	Radium-226[a] (fCi/m³)	Thorium-230[b] (fCi/m³)	Natural uranium[c] (ng/m³)
1	11	<10	0.2	ND	0.3
2	11	<10	.2	ND	1
3	11	22	2	7	10
4	10	15	1	3	2
5	7	100	5	7	3
6	11	190	7	14	4
7	5	<10	.7	ND	.6
8	11	<10	.2	ND	1
9	11	<10	.3	ND	1

[a] Minimum detectable activity for radium-226 — 0.1 pCi/sample.
[b] Minimum detectable activity for thorium-230 — 5.0 pCi/sample.
[c] Minimum detectable activity for natural uranium — 0.1 µg/sample.
ND, nondetectable on composited sample.

Table 5. Atmospheric radon-222, Mexican Hat uranium mill, May–June 1968

Station number	Midpoint of sampling		Radon-222 (pCi/liter)
	Date	Hour	
1	5/27	2030	0.3
2	5/28	2300	.4
3	5/29	2100	1.6
3	6/6	0030	.6
4	5/30	2230	5.7
4	6/4	2400	.7
5	5/31	2100	8.4
5A	6/3	2300	14.0
5B	6/2	2300	13.0
6	6/1	1930	7.5

Table 5 summarizes the radon-222 activity concentrations found at various sampling times and locations. Figure 3 represents the average radon concentrations at each sampling location. Station 1 (a background station) showed a radon concentration of 0.3 pCi/liter. Station 2 (0.4 pCi/liter) can also be considered background level. Those stations on and about the tailings area showed levels of radon significantly above background. Individual samples ranged from a minimum of 0.6 pCi/liter at station 3 to a maximum of 14 pCi/liter at station 5A.

Table 6. Particulate radon daughter products in air, Mexican Hat uranium mill, June 1968

Station number	Collection		Concentration (pCi/m³)		
	Date	Time	Polonium-218	Lead-214	Bismuth-214
5B	6/2	2000	120	90	80
5B	6/3	1100	210	50	10
5A	6/3	1400	10	30	30
5	6/3	1900	0	10	100
5	6/4	1045	0	120	160
4	6/4	1430	0	3	60
3	6/5	1400	220	40	0

Table 7. Long-lived radioactivity in water, Mexican Hat uranium mill, May 1968

Station number	Location	Number of samples	Radium-226 (pCi/liter)	Natural uranium[a] (µg/liter)
1	Wash (spring)	3	1.5	1,690
2	Gypsum Creek	2	.2	1,090
3	Gypsum Creek (spring)	1	.2	1,160
4	Acid blowdown	2	.5	15
Background	Monument Valley	5	.5	2

[a] 1 µg/liter of natural uranium equals 0.7 pCi/liter of alpha radioactivity.

Table 6 summarizes the results of the radon progeny evaluation. It should be noted that the levels of activity are several orders of magnitude lower than the radon concentrations given in table 5. The apparent disequilibrium between polonium-218 and its daughter products may be due in part to poor counting statistics at the low levels of activity counted. It must be assumed, therefore, that a very low state of equilibrium existed between the radon and its progeny during the survey period.

Table 7 shows the average radium-226 and natural uranium in water results for each sampling location. Because there were no suitable ground water sources in the immediate area, ground water samples from the Monument Valley area (approximately 22 miles distant) are used as background indicators. The uranium levels in the ground water samples were significantly above background, averaging between 1,090 μg/liter and 1,690 μg/liter. The acid blowdown water showed a natural uranium concentration of 15 μg/liter which is only slightly above background. Figure 1 shows the average natural uranium concentration for each location.

Table 8 shows the results of the thorium-230, radium-226, and natural uranium analysis on tailings material. The radium content averaged 370 pCi/g. This average is somewhat below that predicted from the average assay of mill feed material (1,000 pCi/g). Thorium-230 averaged 1,960 pCi/g with individual values ranging from a minimum 220 pCi/g to a maximum of 3,700 pCi/g.

Table 8. Tailings analysis, Mexican Hat uranium mill, May 1968

Area	Number	Uranium (μg/g)	Thorium-230 (pCi/g)	Radium-226 (pCi/g)
Tailings #1	1	63	2,400	340
	2	350	3,000	130
	3	69	3,700	31
	4	27	3,200	37
Tailings #2	5	40	2,800	860
	6	70	220	580
	7	73	220	390
	8	470	2,400	550
	9	120	480	320
	10	180	1,200	470
Average		150	1,960	370

Discussion

The Code of Federal Regulations, Title 10, Part 20 (10 CFR 20), indicates a maximum allowable whole body dose to an individual in an unrestricted area of 0.5 rem in any period of 1 calendar year. The regulations further indicate a maximum allowable dose for continuous exposure to individuals in an unrestricted area of 2 millirems in any 1 hour or 100 millirems in 7 consecutive days.

The Radiation Protection Guide (RPG) adopted by the Federal Radiation Council recommends that the yearly radiation exposure to the whole body of individuals in the population (exclusive of natural background and the deliberate exposure of patients by practitioners of the healing arts) should not exceed 0.5 rem (*3*). The Council further recommends, however, that every reasonable effort should be made to keep exposures as far below this level as possible.

To evaluate the potential long-range hazard associated with the external radiation emitted from the tailings material, the average yearly whole-body exposure for an individual having 24-hour-per-day residence on the area was calculated and compared to the recommended RPG of 0.5 rem/a. The net gamma radiation (i.e., minus background) at 3 feet was used for this computation.

The average exposure at the 3-foot level on the tailings area was found to be 0.5 mR/h (background was assumed negligible). The whole-body average yearly dose for an individual having 24-hour-per-day residence on the tailings area, on the basis of this exposure rate, is approximately 4.4 rem/a. This is nine times the recommended RPG of 0.5 rem/a. These findings serve to preclude the release of the tailings area for public use. Action which would permit release of the area would involve covering the tailings with uncontaminated soil to an extent that would diminish the external radiation to an acceptable level and to stabilize the covering against wind erosion. Otherwise, the area should be fenced and controlled as a radiation area.

The average radiation exposure at the 3-foot level around the mill area was 0.15 mR/h. Subtracting an average background of 0.03 mR/h yields an average net exposure of 0.12 mR/h. The yearly average dose to an individual having 24-hour-per-day residence in this area, on the basis of the average value of 0.12 mR/h, is 1 rem/a. This dose is twice the RPG of 0.5 rem/a but represents the highly unlikely condition of continuous occupancy. With reasonable occupancy assumptions it would not be expected that a yearly average dose in excess of 0.5 rem would occur.

The radiation exposure at 3 feet in the housing area was found to consist entirely of background radiation.

In order to assess the potential long-range health hazard associated with the inhalation of airborne radionuclides, the average activity concentrations observed for each sampling station are compared to the recommended radiation concentration guides as indicated in 10 CFR 20. Because the guides are applicable to yearly average concentrations, this comparison assumes that the meteorological conditions imposed during the sampling period are representative of the yearly average conditions.

The radiation concentration guide for unidentified natural radionuclides in air, specified in 10 CFR 20, is 80 fCi/m^3 (when protactinium-231 is assumed absent). If gross alpha radioactivity is above this guide, identification of the specific radionuclides contributing to the total alpha radioactivity is necessary in order to evaluate the potential long-range hazard associated with the inhalation of the airborne particles.

The nuclides in the natural uranium decay chain most significant as potential health hazards are the alpha-particle emitters. These nuclides and their appropriate guides are shown below:

Thorium-230 (soluble)	80 fCi/m^3
Radium-226 (insoluble)	2 pCi/m^3
Natural uranium (insoluble)	2 pCi/m^3
Lead-210 (soluble)	4 pCi/m^3
Polonium-210 (insoluble)	7 pCi/m^3

It is apparent from comparison of these values with table 4 that none of those stations showing elevated gross alpha concentrations exceeds the guides for individual radionuclides. The following conclusions can be made; the tailings pile is resulting in elevated concentrations of radioactivity in air in the downwind direction (at the present time, however, these concentrations cannot be shown to exceed the recommended guides for individual isotopes), and it is impossible to predict whether the condition will be worse in the future. At present, the pile is still quite moist and displays a clay-like consistency. As the pile dries out, the condition could very well become worse. On this basis two courses of action are possible. The tailings area may be stabilized against wind erosion. This action would preclude further carriage of tailings material into the surrounding environment in the future and would eliminate the potential for any long-term hazard to anyone inhabiting the area downwind from the mill property. If the tailings area is not stabilized, periodic monitoring will be necessary to insure that the recommended concentration guides are not exceeded.

The Code of Federal Regulations, Title 10, Part 20, indicates a radiation concentration guide for radon-222 in air in unrestricted areas of 3 pCi/liter above natural background. The daughters of radon-222 are assumed to be present to the extent that they exist in unfiltered air (this is interpreted as meaning equilibrium conditions). To evaluate the potential long-range hazard associated with the inhalation of radon and its progeny, the atmospheric radon concentrations are compared to this guide. Average radon concentrations in the tailings area ranged from a minimum of 3.2 pCi/liter at station 4 to a maximum of 14 pCi/liter at station 5A. These values are equal to or greater than the concentration guide of 3 pCi/liter. It was found, however, that a very low percent equilibrium existed between radon and radon daughters. Since approximately 95 percent of the dose to the lungs due to inhalation of radon and its daughters is due to the particulate daughters, the elevated radon levels cannot be considered as representing violation of the guide. It should be pointed out, however, that if enclosed structures were to be built on the tailings material a substantial increase in both radon and daughters could be expected within the structure; and the radiation concentration guide may be exceeded. Therefore, it is recommended that no enclosed structures be built on the tailings material. Station 3 indicated an average radon concentration of 1.1 pCi/liter. Subtracting natural background gives a net average concentration of 0.8 pCi/liter. This is well below the appropriate concentration guide. The housing area (stations 1, 2) showed essentially background levels of radon-222.

Ground water samples obtained in the vicinity of the tailings area showed natural uranium concentrations in excess of 1 nCi/liter. These values are significantly above background. The Code of Federal Regulations, Title 10, Part 20, indicates a radiation concentration guide for natural

28

uranium of 20 nCi/liter. It is apparent that the concentrations observed are a factor of ten below the recommended guide.

The concentration guide for soluble radium-226 is 30 pCi/liter. None of the samples collected exceeded this guide. It must be concluded, therefore, that although ground water samples in the vicinity of the tailings showed uranium concentrations significantly above background, they are still well below the recommended concentration guides.

Summary

External gamma radiation on the tailings area averaged 0.5 mR/h at 3 feet above the surface. By calculation this comes to a yearly dose of 4.4 rem/a for continuous exposure and exceeds by a factor of nine the recommended Radiation Protection Guide (RPG) of 0.5 rem/a for continuous whole body exposure to individuals in the general population. These findings serve to preclude the release of the tailings area for public use. Action which would permit release of said area would be to cover the tailings with uncontaminated soil to an extent that would diminish the external radiation to an acceptable level and to stabilize the covering against wind erosion. Otherwise, the area should be fenced and controlled as a radiation area.

The tailings pile extends approximately 300 to 500 feet beyond the present property line in the easterly direction. The size of the pile precludes the possibility of returning this material to the property area and therefore this area should be fenced and controlled as a radiation area.

The mill area exhibited external gamma radiation levels averaging 0.12 mR/h above background at 3 feet above the surface. By calculation this comes to a yearly average dose of 1.0 rem for continuous exposure which is two times the appropriate RPG of 0.5 rem/a. With reasonable occupancy assumptions, however, the yearly average dose would probably not exceed 0.5 rem.

The housing area displayed background levels of external radiation.

Airborne transport of tailings material in the northeast direction from the pile is demonstrated by higher than background levels of radioactivity in air. None of the stations showing elevated gross alpha concentrations exceeded the concentration guides for radium-226, thorium-230, or natural uranium, however. Since it is impossible to predict whether the condition will become worse in the future with the drying out of the tailings pile, it is recommended that the area be stabilized against wind erosion. If the area is not stabilized, periodic monitoring will be necessary to insure that the appropriate concentration guides are not exceeded.

The gross alpha radioactivity, radium-226, thorium-230, and natural uranium concentrations in the mill and housing areas were well below the applicable radiation guides.

Average radon gas concentrations on and about the tailings area ranged from 3.2 pCi/liter to 14 pCi/liter. These levels exceed the concentration guide of 3 pCi/liter. It should be pointed out, however, that this guide is applicable to radon-222 and its daughters "as they occur in unfiltered air." This may be interpreted as meaning radon in equilibrium with its daughter products in air. Since it was demonstrated that equilibrium did not exist between radon and its progeny, at least at the time of daughter product sampling, it does not appear that the concentration guide has been exceeded. Levels of radon-222 in the mill area and housing area are substantially below the recommended guide.

It should be emphasized that if enclosed structures were to be built on the tailings material, a substantial increase in radon concentration would occur within the structure and the concentration guide may be exceeded.

Ground water samples obtained in the vicinity of the tailings area showed natural uranium concentrations in excess of 1 nCi/liter. These values represent concentrations substantially above background but are well below the appropriate concentration guide.

Recommendations

On the basis of the data gathered in this survey, it is recommended that the mill tailings be properly stabilized against wind erosion. This action would preclude further transport of tailings material into the surrounding environment and would minimize the potential long-term hazard to anyone inhabiting the area downwind from the mill property. If the tailings area is not stabilized, periodic surveillance will be necessary to insure that significant wind carriage does not occur.

As a result of the external radiation levels on

29

the tailings area itself, this area should not be released for public use in its present state. Action which would permit release of the area would be to cover the tailings with uncontaminated soil to an extent that would diminish the external radiation to an acceptable level and to stabilize the covering against wind erosion.

Acknowledgments

Sincere appreciation is expressed to the A-Z Minerals Corporation for the cooperation and assistance provided during the survey.

REFERENCES

(*1*) SILL, C. An integrating air sampler for determination of ^{222}Rn. Health Physics 16: 371–377 (March 1969).

(*2*) TSIVOGLOU, E. C., H. E. AYER, and D. A. HOLADAY. Occurrence of nonequilibrium atmospheric mixtures of radon and its daughters. Nucleonics 11 (September 1953).

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).

30

SECTION I. MILK AND FOOD

Milk Surveillance, September 1970

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Radiation Office, Environmental Protection Agency, and the Office of Compliance, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports.* Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metaboli-

31

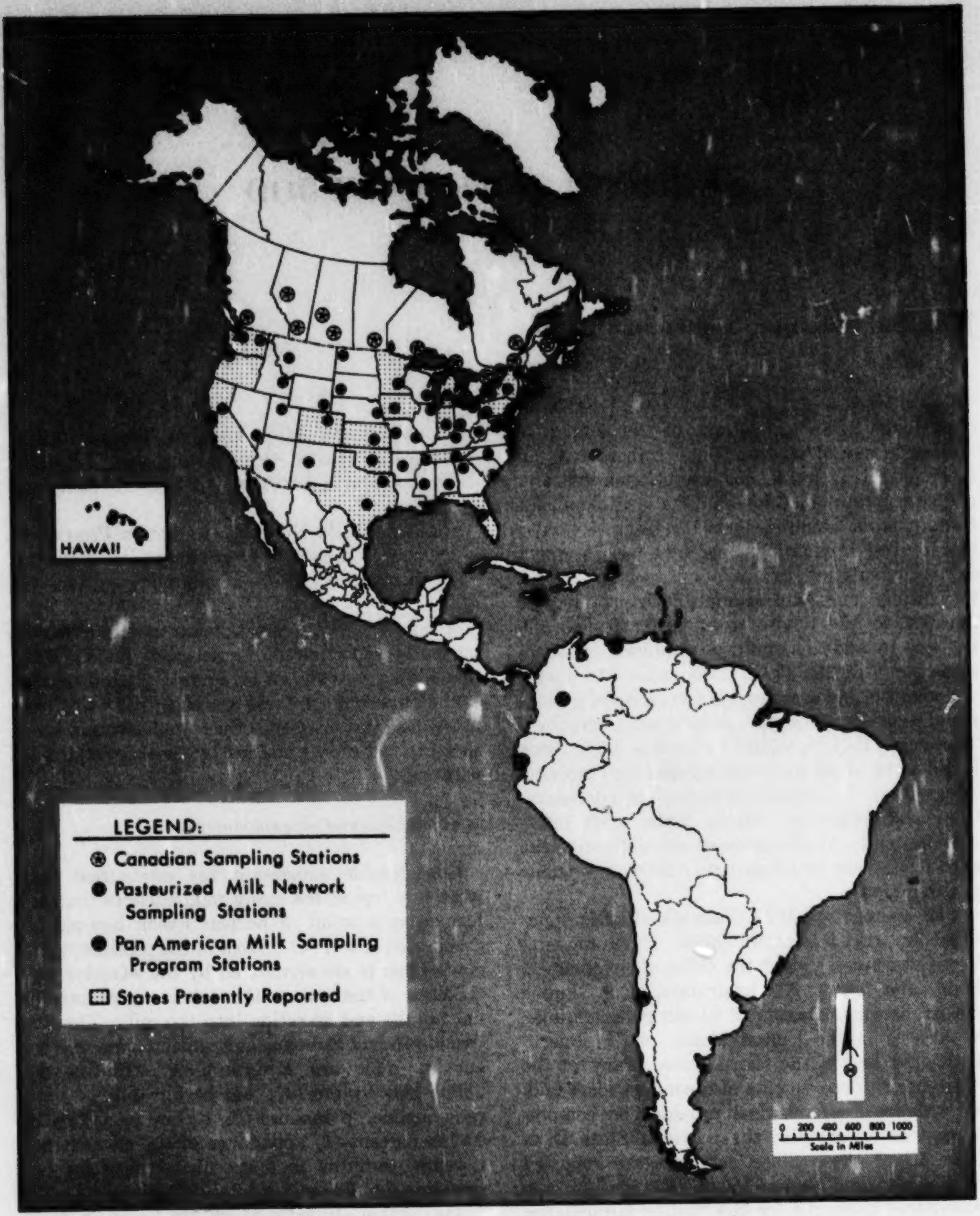

HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
● Pan American Milk Sampling Program Stations
▨ States Presently Reported
0 200 400 600 800 1000
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere

cally similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2-standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during May–July 1970, with 28 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 (*5*). Of the 20 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 13 participated in the experiment.

The accuracy results of this experiment are shown in table 1. In general, considerable improvement is needed, especially in the accuracy measurements. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category			
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Strontium-89: High (258 pCi/liter)	7 (44%)	1 (6%)	8 (50%)	16
Low (15 pCi/liter)	11 (69%)	3 (19%)	2 (12%)	16
Strontium-90: Intermediate (79.4 pCi/liter)	13 (57%)	4 (17%)	6 (26%)	23
Low (32.0 pCi/liter)	5 (25%)	4 (20%)	11 (55%)	20
Iodine-131: High (507 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
Low (49 pCi/liter)	16 (64%)	3 (12%)	6 (24%)	25
Cesium-137: High (259 pCi/liter)	20 (74%)	3 (11%)	4 (15%)	27
Low (53 pCi/liter)	17 (66%)	5 (19%)	4 (15%)	26
Barium-140: High (302 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
Low (33 pCi/liter)	23 (92%)	0	2 (8%)	25

[a] Measured concentration less than or equal to 2σ of the known concentration.
[b] Measured concentration greater than 2σ and less than or equal to 3σ of the known concentration.
[c] Measured concentration greater than 3σ of the known concentration.

by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short time periods, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. An analysis of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in connection of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels are given as equal or to less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4-10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity

Table 2. Concentrations of radionuclides in milk for September 1970 and 12-month period October 1969 through September 1970

Sampling location		Type of sample[a]	Strontium-90 Monthly average[b]	Strontium-90 12-month average	Iodine-131 Monthly average[b]	Iodine-131 12-month average	Cesium-137 Monthly average[b]	Cesium-137 12-month average
			Radionuclide concentration (pCi/liter)					
UNITED STATES:								
Ala:	Montgomery[c]	P	NA	6	0	0	12	9
Alaska:	Palmer[c]	P	7	5	0	0	0	8
Ariz:	Phoenix[c]	P	NA	1	0	0	0	0
Ark:	Little Rock[c]	P	12	13	0 (2)	0	15 (2)	17
Calif:	Sacramento[c]	P	NA	1	0	0	0	0
	San Francisco[c]	P	NA	2	0	0	0	0
	Del Norte	P	15	17	0	0	6	19
	Fresno	P	2	2	0	0	0	2
	Humboldt	P	4	5	0	0	0	3
	Los Angeles	P	2	2	0	0	0	2
	Mendocino	P	4	3	0	0	0	3
	Sacramento	P	2	2	0	0	0	2
	San Diego	P	2	2	0	0	0	1
	Santa Clara	P	1	2	0	0	0	1
	Shasta	P	2	3	0	0	0	2
	Sonoma	P	2	3	0	0	0	3
Colo:	Denver[c]	P	NA	5	0	0	0	1
	West	R	(d)		(e)10	(e)10	(e)10	4
	Northeast	R	(d)		(e)10 (3)	(e)10	(e)10 (2)	(e)10
	East	R	(d)		(e)10	(e)10	(e)10	(e)10
	Southeast	R	(d)		NS	(e)10	NS	(e)10
	South central	R	(d)		NS	NS	NS	NS
	Southwest	R	(d)		(e)10	(e)10	(e)10	(e)13
	Northwest	R	(d)		(e)10	(e)10	(e)10	(e)10
Conn:	Hartford[c]	P	NA	7	0	0	13	12
	Central	P	6	7	0	0	15	13
Del:	Wilmington[c]	P	NA	9	0	0	0	6
D.C.:	Washington[c]	P	NA	8	0	0	0	6
Fla:	Tampa[c]	P	5	6	0	0	59	51
	West	R	12	10	0	0	19	22
	North	R	7	11	0	0	0	23
	Northeast	R	6	6	0	0	50	40
	Central	R	NA	7	0	0	20	52
	Tampa Bay area	R	6	6	0	0	57	47
	Southeast	R	6	7	0	0	76	71
Ga:	Atlanta[c]	P	NA	10	0	0	12	16
Hawaii:	Honolulu[c]	P	3	2	0	0	0	0
Idaho:	Idaho Falls[c]	P	6	5	0	0	0	4
Ill:	Chicago[c]	P	7	8	0	0	13	9
Ind:	Indianapolis[c]	P	NA	8	0	0	0	5
	Northeast	P	8	9	3	1	15	14
	Southeast	P	8	11	0	0	10	12
	Central	P	6	9	15	1	10	10
	Southwest	P	10	11	0	0	10	12
	Northwest	P	9	10	0	0	20	15
Iowa:	Des Moines[c]	P	NA	6	0	0	0	2
	Iowa City	P	7	8	0	0	11	10
	Des Moines	P	9	8	0 (5)	0	3	6
	Spencer	P	6	6	0	0	0	5
	Fredericksburg	P	NS	NS	NS	NS	NS	NS
Kans:	Wichita[c]	P	NA	8	0	0	0	1
	Coffeyville	P	7	10	0	0	0	0
	Dodge City	P	9	9	0	0	0	1
	Falls City	P	0	14	0	0	13	2
	Hays	P	12	13	13	1	0	0
	Kansas City	P	15	9	0	0	11	3
	Topeka	P	3	11	0	0	0	2
	Wichita	P	8	10	0	0	0	0
Ky:	Louisville[c]	P	NA	8	0	0	0	4
La:	New Orleans[c]	P	14	15	0	0	19	18
Maine:	Portland[c]	P	NA	10	0	0	13	21
Md:	Baltimore[c]	P	NA	8	0	0	12	8
Mass:	Boston[c]	P	9	10	0	0	23	21
Mich:	Detroit[c]	P	NA	8	0	0	13	10
	Grand Rapids[c]	P	NA	9	0	0	16	12
	Bay City	P	NA	7	(e)10	(e)10	11	10
	Charlevoix	P	10	12	(e)10 (4)	(e)10	15 (4)	16
	Detroit	P	7	8	(e)10	(e)10	0	7
	Grand Rapids	P	9	9	(e)10	(e)10	0	9
	Lansing	P	NA	9	(e)10 (2)	(e)10	10 (2)	15
	Marquette	P	NA	14	(e)10	(e)10	19	22
	Monroe	P	5	6	(e)10 (2)	(e)10	0 (2)	4
	South Haven	P	8	8	(e)10 (4)	(e)10	4 (4)	7
Minn:	Minneapolis[c]	P	NA	10	0	0	15	8
	Bemidji	P	10	10	0	0	26	21
	Mankato	P	7	4	0	0	0	11
	Rochester	P	7	6	0	0	0	11
	Duluth	P	13	14	0	0	20	26
	Worthington	P	3	4	0	0	0	0
	Minneapolis	P	10	9	0	0	14	14
	Fergus Falls	P	7	5	0	0	16	13
	Little Falls	P	15	10	0	0	27	22

See footnotes at end of table.

35

Table 2. Concentrations of radionuclides in milk for September 1970 and 12-month period October 1969 through September 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
Miss:	Jackson[c]	P	NA	12	0	0	0	11
Mo:	Kansas City[c]	P	NA	8	0	0	9	2
	St. Louis[c]	P	NA	8	0	0	0	3
Mont:	Helena[c]	P	NA	5	0	0	22	8
Nebr:	Omaha[c]	P	NA	6	0	0	0	1
Nev:	Las Vegas[c]	P	NA	2	0	0	0	0
N.H:	Manchester[c]	P	NA	8	0	0	22	13
N.J:	Trenton[c]	P	NA	8	0	0	11	9
N.Mex:	Albuquerque[c]	P	NA	2	0	0	0	0
N.Y:	Buffalo[c]	P	8	7	0	0	0	8
	New York City[c]	P	NA	9	0	0	24	16
	Syracuse[c]	P	NA	7	0	0	0	10
	Albany	P	7	5	0 (5)	0	0	0
	Buffalo	P	(e)10	(e)[illegible]	0	0	0	0
	Massena	P	11	7	0 (2)	0	20	0
	Newburgh	P	8	7	0 (2)	0	0	0
	New York City	P	14	8	0	0	0	0
	Syracuse	P	(e)10	3	0	0	0	0
N.C:	Charlotte[c]	P	NA	11	0	0	22	14
N.Dak:	Minot[c]	P	NA	9	0	0	0	14
Ohio:	Cincinnati[c]	P	NA	8	0	0	0	8
	Cleveland[c]	P	NA	9	0	0	13	8
Okla:	Oklahoma City[c]	P	NA	6	0	0	0	5
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Oreg:	Portland[c]	P	3	8	0	0	0	5
	Baker	P	NA	3	ND	<0	18	3
	Coos Bay	P	NA	5	ND	<0	24	14
	Eugene	P	NA	3	ND	<0	16	4
	Medford	P	NA	2	ND	<0	24	10
	Portland composite	P	NA	4	ND	<0	19	6
	Portland local	P	NA	4	ND	<0	11	6
	Redmond	P	NA	2	ND	<0	<0	3
	Tillamook	R	NA	5	ND	<0	28	16
Pa:	Philadelphia[c]	P	NA	9	0	0	0	5
	Pittsburgh[c]	P	NA	10	0	0	16	11
	Dauphin	P	9	7	0	3	11	14
	Erie	P	0	11	0	3	26	20
	Philadelphia	P	0	9	0	3	20	15
	Pittsburgh	P	10	12	0	2	14	21
R.I:	Providence[c]	P	NA	8	0	0	21	16
S.C:	Charleston[c]	P	7	10	0	1	16	20
S.Dak:	Rapid City[c]	P	6	7	0	0	0	4
Tenn:	Chattanooga[c]	P	NA	9	0	0	0	11
	Memphis[c]	P	NA	8	0	0	14	7
	Chattanooga	P	10	10	0	0	11	13
	Clinton	P	10	12	0	0	0	13
	Fayetteville	P	11	12	0	0	0	10
	Knoxville	P	9	8	0 (2)	0	9 (2)	7
	Nashville	P	5	7	0 (2)	0	0 (2)	6
Tex:	Austin[c]	P	NA	3	0	0	0	3
	Dallas[c]	P	NA	6	0	0	0	7
	Amarillo	R	5	4	0	0	0	2
	Corpus Christi	R	NS	4	NS	0	NS	2
	El Paso	R	NS	3	NS	0	NS	0
	Fort Worth	R	NS	5	NS	0	NS	2
	Harlingen	R	0	3	0	0	0	0
	Houston	R	NS	8	NS	0	NS	11
	Lubbock	R	NS	4	NS	0	NS	0
	Midland	R	NS	3	NS	0	0	0
	San Antonio	R	3	4	0	0	NS	0
	Texarkana	R	NS	8	NS	0	NS	5
	Tyler	R	NS	15	NS	0	NS	17
	Uvalde	R	NS	2	NS	0	NS	0
	Wichita Falls	R	NS	9	NS	0	NS	5
Utah:	Salt Lake City[c]	P	4	5	0 (2)	0	13 (2)	5
Vt:	Burlington[c]	P	NA	8	0	0	19	13
Va:	Norfolk[c]	P	8	9	0	0	0	9
Wash:	Seattle[c]	P	NA	5	0	0	0	2
	Spokane[c]	P	NA	6	0	0	0	2
	Benton County	R	0	0	0	0	0	5
	Franklin County	R	NS	2	NS	0	NS	3
	Sandpoint, Idaho	R	11	10	0	0	23	22
	Skagit County	R	6	6	0	0	0	8
W.Va:	Charleston[c]	P	NA	8	0	0	12	5
Wis:	Milwaukee[c]	P	NA	6	0	0	13	11
Wyo:	Laramie[c]	P	NA	5	0	0	0	1

See footnotes at end of table.

36

Table 2. Concentrations of radionuclides in milk for September 1970 and 12-month period October 1969 through September 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA:								
Alberta:	Calgary	P	8	8	(d)		9	17
	Edmonton	P	11	9	(d)		22	17
British Columbia:								
	Vancouver	P	9	10	(d)		30	27
Manitoba:	Winnipeg	P	6	7	(d)		27	25
New Brunswick:								
	Fredericton	P	15	13	(d)		24	21
Newfoundland:								
	St. Johns	P	20	18	(d)		29	28
Nova Scotia:	Halifax	P	12	10	(d)		24	20
Ontario:	Thunder Bay	P	13	12	(d)		30	28
	Ottawa	P	6	6	(d)		16	14
	Sault Ste. Marie	P	16	14	(d)		28	21
	Toronto	P	4	4	(d)		8	10
	Windsor	P	5	5	(d)		9	10
Quebec:	Montreal	P	8	7	(d)		13	18
	Quebec	P	8	10	(d)		30	28
Saskatchewan:								
	Regina	P	8	7	(d)		11	14
	Saskatoon	P	9	9	(d)		21	13
CENTRAL AND SOUTH AMERICA:								
Colombia:	Bogota	P	0	0	0	0	0	0
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Montego Bay	P	NS	4	NS	0	NS	78
Venezuela:	Caracas	P	3	1	0	0	0	0
Canal Zone:	Cristobal[c]	P	NA	1	0	0	15	10
Puerto Rico:	San Juan[c]	P	0	3	0	0	14	7
PMN Network average[f]			7	7	0	0	8	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado–25 pCi/liter
Michigan–14 pCi/liter
Oregon–15 pCi/liter

Cesium-137: Colorado–25 pCi/liter
New York–20 pCi/liter
Oregon–15 pCi/liter

Strontium-90: New York-3 pCi/liter

[f] This entry gives the average radionuclides concentrations for the PHS Pasteurized Milk Network stations denoted by footnote c.
NA, no analysis.
NS, no sample collected.

in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radio-

37

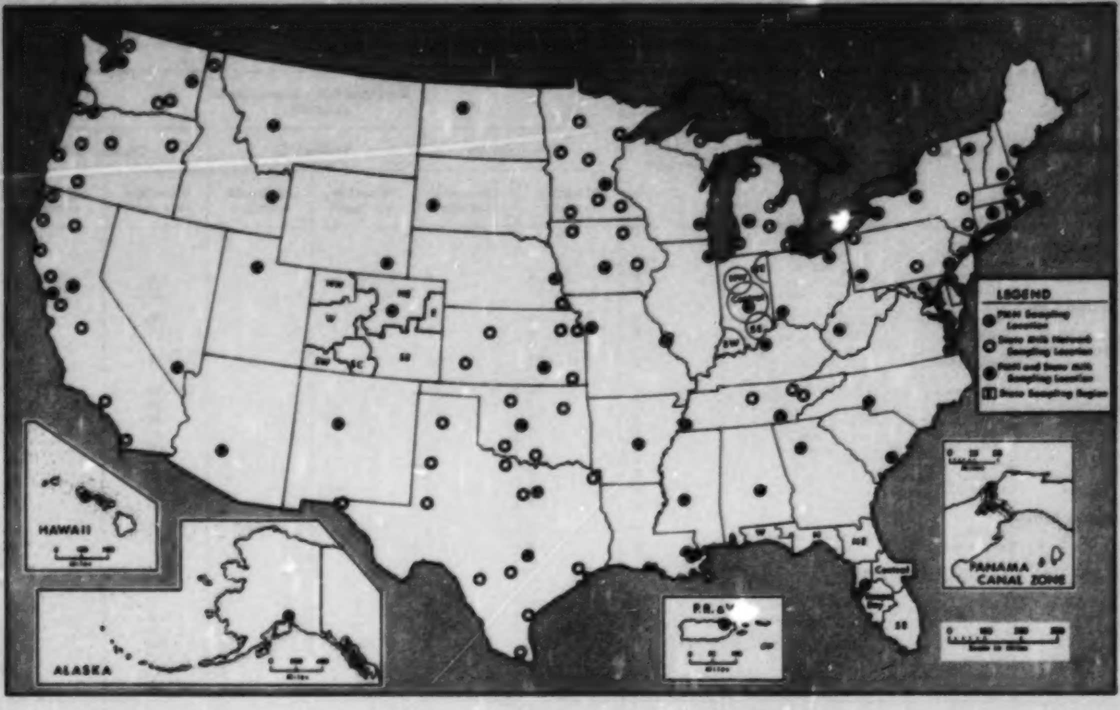


Figure 2. State and PMN milk sampling locations in the United States

activity by exposed populations groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90, iodine-131, and cesium-137 for September 1970 and the 12-month period, October 1969 to September 1970. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for September 1970 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89 or barium-140 were detected.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council, levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Table 3. Strontium-89 and barium-140 in milk September 1970

Sampling location		Radionuclide concentration (pCi/liter)	
		Strontium-89	Barium-140
Kans:	Coffeyville (State)	6	
	Dodge City (State)		11
	Falls City (State)		13
	Kansas City (State)		11
	Topeka (State)	10	
Chile:	Santiago	20	
Ecuador:	Guayaquil	10	

Strontium-90 monthly averages ranged from 0 to 15 pCi/liter in the United States for September 1970 and the highest 12-month average was 17 pCi/liter (Del Norte, Calif.) representing 3.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 76 pCi/liter in the United States for September 1970, and the highest 12-month average was 71 pCi/liter (Southeast Fla.), representing 2.0 percent of the value derived from Federal Radiation Council recommendations. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica. Iodine-131 results for individual samples were all below the practical reporting level, with the exception of Hays, Kans. (State), 13 pCi/liter, and central Indiana (State), 15 pCi/liter, for September 1970.

The Canadian Department of National Health and Welfare have made recent changes in the frequency of analyses of samples from the network. Samples are collected on a weekly basis and shipped to Ottawa where they are further composited to make a monthly sample for each station. The monthly sample is gamma-scanned and analyzed for cesium-137 and potassium. Aliquots from the monthly samples are composited to make a quarterly sample for each station. The quarterly sample is analyzed for strontium-90 and calcium.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiological Health Section
Division of Air, Occupational and
Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Nuclear Engineering
New York State Department of Environmental
Conservation

Division of Occupational and Radiological
Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

REFERENCES

(*1*) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER, and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Public Health 49:225 (February 1959).

(*2*) Chart of the Nuclides, Ninth Edition revised to July 1966. Knolls Atomic Power Laboratory (November 1966).

(*3*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

(*4*) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(*5*) KNOWLES, F. Interlaboratory study of iodine-131, cesium-137, barium-140, strontium-89, and strontium-90 measurements in milk, May–July 1970, Technical experiment 70-MKAQ-1. Analytical Quality Control Service, Bureau of Radiological Health (September 1970).

(*6*) NEILL, R. H. and D. R. SNAVELY. State Health Department sampling criteria for surveillance of radioactivity in milk. Radiol Health Data Rep 8:621–627 (November 1967).

(*7*) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

(*8*) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER, and B. KAHN. The cause of relatively high cesium-137 concentrations in Tampa, Florida, milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y., (1966), pp. 95–101.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiological Health Data and Reports* are shown below.

Program	Period reported	Issue
California Diet Study	January–June 1970	November 1970
Carbon-14 and Tritium in Total Diet and Milk	January 1969–June 1970	January 1971
Connecticut Standard Diet	July–December 1969	December 1970
Institutional Diet Samples	January–March 1970	November 1970
Strontium-90 in Tri-City Diets	January–December 1969	June 1970

1. Radionuclides in Institutional Diet Samples April-June 1970

Bureau of Radiological Health and *Food and Drug Administration*

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Bureau of Radiological Health with the assistance of the Office of Compliance, Food and Drug Administration (*1*).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. At the present time 19 basic institutions and eight auxiliary institutions, distributed geographically as shown in figure 1, are being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1*, *2*). Consequently, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev; the Southeastern Radiological Health Laboratory, Montgomery, Ala; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented earlier (*3*).

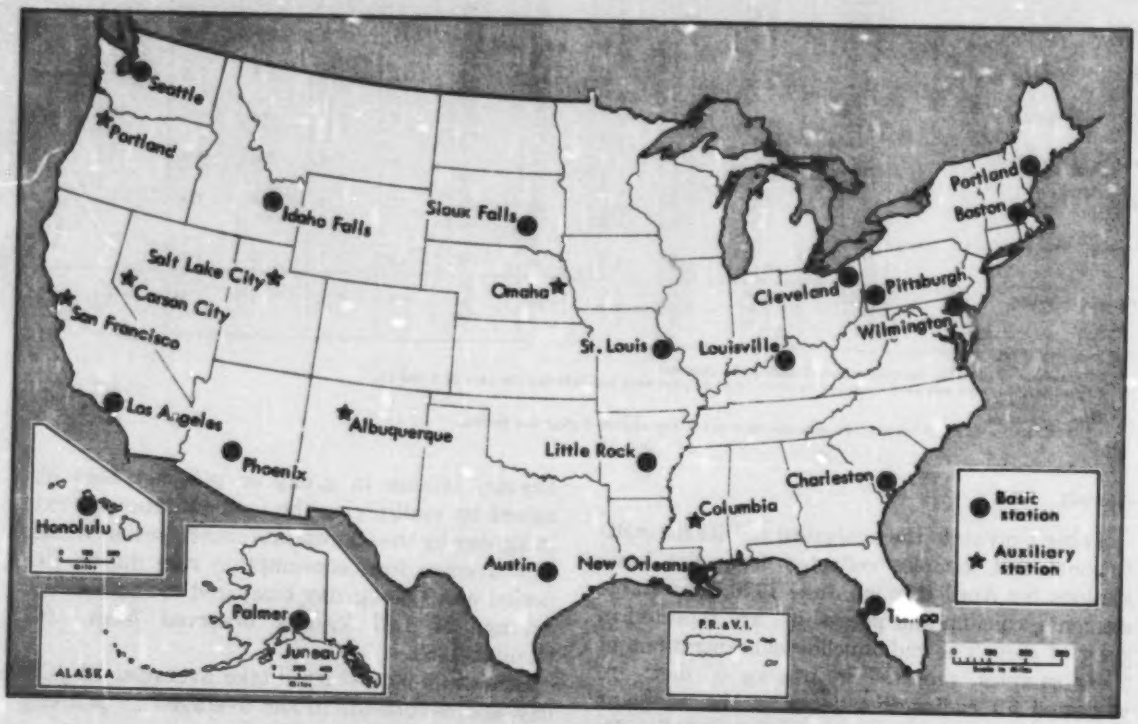

Seattle
Portland
Idaho Falls
Sioux Falls
Salt Lake City
Carson City
San Francisco
Omaha
Los Angeles
Phoenix
Albuquerque
St. Louis
Louisville
Cleveland
Pittsburgh
Wilmington
Portland
Boston
Little Rock
Charleston
Columbia
Austin
New Orleans
Tampa
Honolulu
Palmer
Juneau
ALASKA
P.R. & V.I.
● Basic station
★ Auxiliary station

Figure 1. Institutional diet sampling locations as of June 1970

Table 1. Concentration and intake of stable elements and radionuclides in institutional total diets of children (basic stations), April–June 1970

Location of Institution		Month (1970)	Total weight (kg/day)	Potassium		Cesium-137		Calcium[a]		Strontium-89[a]		Strontium-90[a]	
				(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska:	Palmer	April	NS										
		May	NS										
		June	1.06	1.5	1.5	22	23	0.7	0.7	0	0	9	9
Ariz:	Phoenix	April	NS										
		May	NS										
		June	1.5	1.4	2.1	0	0	.7	1.1	0	0	9	14
Ark:	Little Rock	April[b]	1.12	1.5	1.7	12	13	.6	0.7	NA	NA	9	10
		May	1.14	1.5	1.8	22	25						
		June[b]	1.14	1.7	1.9	14	16						
Calif:	Los Angeles	April	NS										
		May	NS										
		June[b]	1.37	1.2	1.6	0	0	.5	0.7	0	0	5	6
Del:	Wilmington	April	1.50	1.5	2.1	0	0	.6	1.2	NA	NA	6	12
		May	2.28	1.5	3.4	0	0						
		June	1.88	1.5	2.8	15	28						
Fla:	Tampa	April	1.42	1.5	2.0	18	26	.7	1.1	NA	NA	8	12
		May[b]	1.39	1.5	2.1	20	28						
		June	1.82	1.7	3.0	37	68						
Hawaii:	Honolulu	April	NS										
		May	NS										
		June[b]	2.12	1.5	3.1	0	0	.5	1.1	0	0	0	0
Idaho:	Idaho Falls	April[b]	1.88	1.6	3.0	13	25	1.2	2.3	0	0	9	17
		May[b]	1.53	1.5	2.3	0	0						
		June[b]	1.97	1.7	3.3	12	24						
Ky:	Louisville	April	2.52	1.6	4.1	15	38	.6	1.5	NA	NA	7	19
		May	2.60	1.9	4.9	18	47						
		June	2.65	1.9	4.9	18	48						
La:	New Orleans	April[b]	1.89	1.6	3.1	0	0	.6	1.0	NA	NA	10	17
		May[b]	1.67	1.6	2.7	12	20						
		June[b]	1.37	1.1	1.6	0	0						
Maine:	Portland	April	1.81	1.9	3.4	15	27	.9	1.6	NA	NA	11	19
		May	1.81	1.6	2.9	13	24						
		June	1.75	1.6	2.8	14	25						
Mass:	Boston	April	2.32	1.4	3.1	12	27	.8	1.2	0	0	7	15
		May	2.02	1.8	3.6	18	36						
		June	2.08	1.4	2.9	0	0						
Mo:	St. Louis	April[b]	2.37	1.7	4.0	14	33	1.2	2.7	NA	NA	7	15
		May[b]	2.11	1.9	4.0	0	0						
		June[b]	2.27	1.9	4.3	13	30						
Ohio:	Cleveland	April	1.24	1.8	2.2	0	0	.6	0.8	NA	NA	7	10
		May[b]	1.45	1.6	2.3	0	0						
		June	1.35	1.7	2.3	0	0						
Pa:	Pittsburgh	April	2.35	1.4	3.3	0	0	.5	1.2	NA	NA	6	13
		May	2.27	1.3	3.0	14	32						
		June	2.35	1.3	2.9	12	27						
S.C:	Charleston	April[b]	2.12	1.4	2.9	20	42	.7	1.5	NA	NA	10	23
		May	2.45	1.4	3.5	12	29						
		June	2.22	1.3	3.0	20	44						
S. Dak:	Sioux Falls	April[b]	1.35	1.9	2.6	0	0	.8	1.0	NA	NA	5	7
		May[b]	1.20	1.5	1.8	0	0						
		June[b]	1.20	1.6	1.9	0	0						
Tex:	Austin	April[b]	2.36	1.5	3.5	0	0	.8	1.5	NA	NA	3	6
		May[b]	1.80	1.6	2.9	16	29						
		June[b]	1.75	1.6	2.9	0	0						
Wash:	Seattle	April	NS										
		May	NS										
		June[b]	2.00	1.3	2.6	0	0	.5	1.1	0	0	7	13
Network average		April	1.86	1.6	3.0	9	17	0.7	1.3	0	0	7	12
		May	1.84	1.6	2.9	10	19						
		June	1.78	1.5	2.7	9	18						

[a] Composite of monthly samples collected during the quarter.
[b] Food samples were collected from two or more children who were not between the ages of 9 and 12.
NA, no analysis.
NS, no sample.
NOTE: Iodine-131 and barium-140 were not detected at any station during this period.

Results

Table 1 presents the analytical results for institutional diet samples collected from the basic stations for April through June 1970. The stable elements, calcium and potassium, are reported in g/kg of diet. The radionuclide concentrations of these samples, reported in pCi/kg of diet, are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.83 kg/day compared to the network average of 1.87 kg/day observed from 1961 through 1969.

Strontium-90 dietary intake averaged 12 pCi/day and cesium-137 intake averaged 18 pCi/day

Table 2. Concentration and intake of stable elements and radionuclides in institutional total diets of children (auxiliary stations), April–June 1970

Location of Institution		Month (1970)	Total weight (kg/day)	Potassium		Cesium-137		Calcium^a		Strontium-89^a		Strontium-90^a	
				(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska:	Juneau	April	NS										
		May	NS										
		June	1.46	1.4	2.1	0	0	0.5	0.8	0	0	4	6
Calif:	San Francisco	April	NS										
		May	NS										
		June	NS										
Miss:	Columbia	April	1.91	1.6	3.0	16	31	1.1	2.1	NA	NA	10	20
		May	2.06	1.5	3.0	18	37						
		June	1.83	1.4	2.5	16	29						
Nebr:	Omaha	April	2.35	1.8	4.3	12	28	.8	1.8	NA	NA	6	11
		May	1.99	1.6	3.2	0	0						
		June	1.89	1.6	3.0	0	0						
Nev:	Carson City	April	NS										
		May	NS										
		June	1.32	1.4	1.8	0	0	.9	1.2	0	0	7	9
N. Mex:	Albuquerque	April	2.12	1.4	3.0	0	0	.9	2.0	NA	NA	3	6
		May	2.15	1.5	3.2	0	0						
		June	2.50	1.7	4.3	0	0						
Oreg:	Portland	April	NS										
		May	NS										
		June	1.56	1.9	3.0	0	0	.5	.8	7	11	0	0
Utah:	Salt Lake City	April	NS										
		May	2.20	1.2	2.7	0	0	.5	1.2	0	0	0	0
		June	NS										
Network average		April	2.13	1.6	3.4	9	20	0.7	1.4	1	2	4	7
		May	2.13	1.5	3.0	5	9						
		June	1.76	1.6	2.8	3	5						

^a Composite of monthly samples collected during the quarter.
NA, no analysis.
NS, no sample.
NOTE: Iodine-131 and barium-140 were not detected at these stations during this period.

during this period. These results fall within Range I as defined by the Federal Radiation Council (4). Strontium-89, barium-140, and iodine-131 concentrations were below detectable levels.

All concentrations that are less than or equal to the appropriate minimum detectable level have been reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2-standard deviation analytical error. Accordingly, the minimum detectable limits are as follows:

Strontium-89	5 pCi/kg
Strontium-90	2 pCi/kg
Iodine-131	10 pCi/kg
Barium-140	10 pCi/kg
Cesium-137	10 pCi/kg

Data from eight auxiliary stations are included in table 2 for general information. These stations do not meet the criterion that the majority of the samples are collected from children who range in age from 9 to 12 years. In order to supplement the existing environmental monitoring networks of the Bureau of Radiological Health, these eight institutions are being sampled in the same manner as the basic stations.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July–September 1969	June 1970
October–December 1969 and Annual Summary, 1969	August 1970
January–March 1970	November 1970

REFERENCES

(1) ANDERSON, E. C., D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(2) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Radiol Health Data 6:548–554 (October 1965).

(3) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1968. Radiol Health Data Rep 9:557–560 (October 1968).

(4) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

43

Carbon-14 and Tritium in Total Diet and Milk January 1969-June 1970

Bureau of Radiological Health
U.S. Public Health Service

The Bureau of Radiological Health initiated a program in July 1965 to determine the levels of carbon-14 and tritium in the total diet and milk in the United States. Initially, monthly samples from each of the PHS Institutional Total Diet Sampling Network (ITDSN) and Pasteurized Milk Network (PMN) stations were composited and analyzed according to six selected regions: Northeast, South, Delta, Central, Southwest, and Northwest. Figure 1 shows the ITDSN and PMN sampling stations in each of the designated regions.

In January 1966, the program was modified to include selected stations in each of the previously mentioned regions plus Alaska and Hawaii. The nine geographically distributed sampling stations are: Palmer, Alaska; Honolulu, Hawaii; Idaho Falls, Idaho; Chicago, Ill; New Orleans, La; Boston, Mass; Portland, Oreg; and Charleston, S.C. Los Angeles, Calif. is not a PMN station, but a special milk sample is collected for purposes of comparison with the routine ITDSN sample.

A 1-liter milk sample and a 2-kilogram food sample are sent to the PHS Northeastern Radiological Health Laboratory for analysis. The milk samples analyzed represent a composite of the samples collected during the last 2 weeks of the month, and the total diet samples analyzed represent the samples collected for that month.

The carbon-14 analyses are performed semiannually and the tritium analyses were performed monthly through June 1969. Tritium analyses were discontinued then because the results were only slightly above the limit of detectability and were less than 1 percent of the maximum permissible concentration for milk and food consumed by the general population.

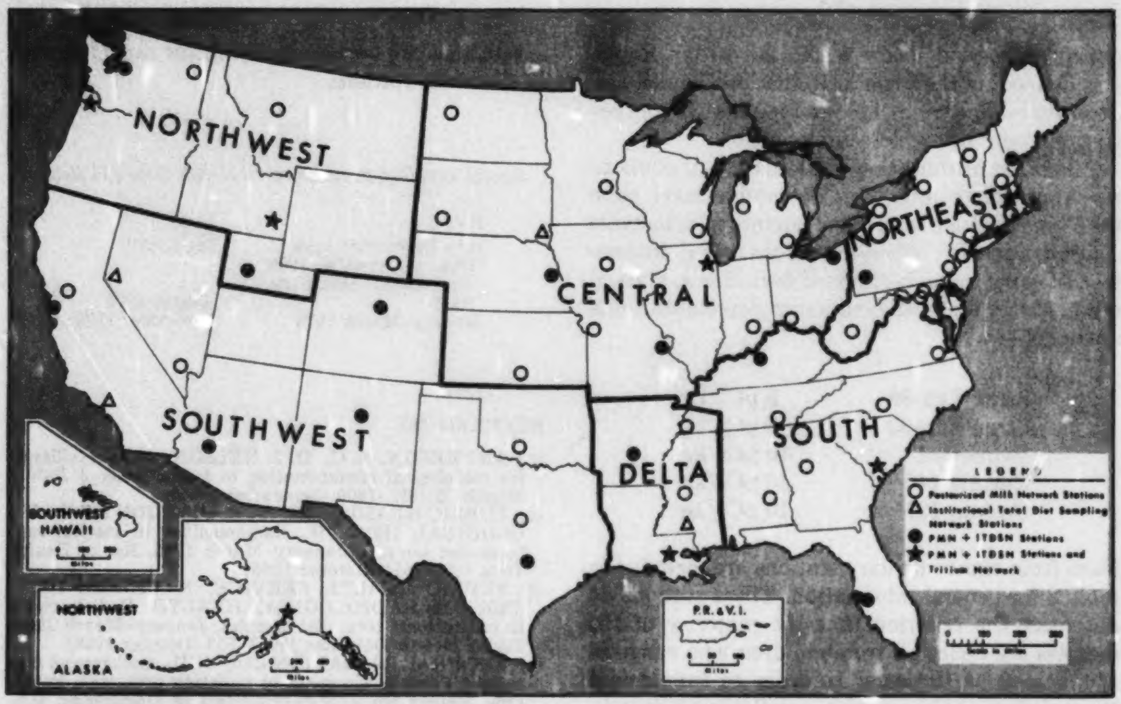

NORTHWEST
CENTRAL
NORTHEAST
SOUTHWEST
DELTA
SOUTH
SOUTHWEST
HAWAII
NORTHWEST
ALASKA
P.R. & V.I.
LEGEND
○ Pasteurized Milk Network Stations
△ Institutional Total Diet Sampling Network Stations
● PMN + ITDSN Stations
★ PMN + ITDSN Stations and Tritium Network
Scale in Miles
Miles

Figure 1. ITDSN and PMN sampling stations

Table 1. Carbon-14 in total diet and milk, January 1969–June 1970

Location		Date collected	Concentration (pCi/kg ±2σ)	
			Total diet	Milk
Alaska:	Palmer	April 1969	1,040±50	560±35
		October 1969	880±46	500±30
		March 1970	910±42	470±22
Calif:	Los Angeles	April 1969	980±35	510±18
		October 1969	1,000±33	490±21
		March 1970	900±31	
		April 1970		490±22
Hawaii:	Honolulu	April 1969	990±37	480±19
		October 1969	950±44	470±18
		April 1970	NS	NS
Idaho:	Idaho Falls	April 1969	1,080±31	500±19
		October 1969	980±40	490±19
		April 1970	1,040±33	510±17
Ill:	Chicago	April 1969	NS	470±14
		October 1969	NS	460±24
		April 1970	NS	450±22
La:	New Orleans	April 1969	1,020±39	510±14
		October 1969	1,040±34	490±16
		April 1970	780±41	
		May 1970		450±22
Mass:	Boston	April 1969	1,070±53	490±21
		October 1969	1,040±33	480±17
		April 1970	1,000±31	400±22
Oreg.	Portland	April 1969	1,160±40	480±18
		October 1969	1,140±34	490±13
		March 1970	830±51	
		April 1970		520±18
S. C:	Charleston	April 1969	850±40	490±52
		October 1969	1,000±43	510±13
		April 1970	840±30	
		May 1970		410±22

NS, no sample.

Analytical procedures

The carbon-14 content is determined by combustion of the milk or food sample and collection and purification of the evolved carbon dioxide. The carbon dioxide is then converted to methane and counted in a gas-proportional counter (*1*). Water simultaneously produced by the combustion is used for the tritium determination. When only the tritium analysis is required, the sample is distilled to dryness and the collected water is used for the determination. In some cases, the sample is electrolytically enriched (*1*) prior to liquid scintillation counting.

Results and discussion

The carbon-14 concentration in food and milk was measured as dpm of carbon-14 per gram of carbon and converted to pCi/kg by using the percent carbon in the sample. The carbon content in food ranged from 9.9 percent to 13.6 percent with an average of 11.9 percent, and the carbon content in milk ranged from 3.3 percent to 7.3 percent with an average of 5.8 percent.

For the tritium measurements, the water content per kilogram of food ranged from 71.1 percent to 95.6 percent with an average of 91.0 percent. The water content of milk is assumed to be 97 percent. The average carbon and water content were used for the calculation of activity per kilogram.

Tables 1 and 2 show the carbon-14 and tritium concentrations in total diet and milk for January 1969–June 1970. Table 3 shows the mean carbon-14 concentrations for all stations for the periods indicated. The data show a gradual downward trend. The mean tritium concentrations in table 4 show a decrease of about a factor of 2 since July 1965. The values for July 1965–December 1968 have been previously published (*2*).

Other coverage in *Radiological Health Data and Reports:*

Period	Issue
July 1965–December 1968	November 1969

REFERENCES

(*1*) DROBINSKI, J. C. JR., D. P. LAGATTA, A. S. GOLDIN, and J. G. TERRILL. Analyses of environmental samples for carbon-14 and tritium. Health Phys 11:385–395 (1965).

(*2*) BUREAU OF RADIOLOGICAL HEALTH. Carbon-14, tritium, and plutonium-239 in milk and total diet, July 1965 to December 1968. Radiol Health Data Rep 10:500–505 (November 1969).

45

Table 2. Tritium content of total diet and milk, January–June 1969

Location		Date collected (1969)	Concentration (nCi/kg ±2σ)	
			Total diet	Milk
Alaska:	Palmer	January	1.9± .7	1.0± .7
		February	1.8± .8	[a] .7±1.2
		March	[b] .9± .2	[b] .9± .4
		April	[a] .4± .6	[a] 1.3±1.3
		May	1.0± .5	[a] .3± .5
		June	1.0± .3	1.3± .3
Calif:	Los Angeles	January	NS	.9± .7
		February	[b] .4± .3	[a,b] 0± .3
		March	[a] .5± .7	1.2± .7
		April	[a] 0± .7	[a] .3± .7
		May	[a] 1.0±1.5	NS
		June	[a] .2± .3	[a] .3± .4
Hawaii:	Honolulu	January	1.8± .7	[a] .6± .9
		February	1.1± .8	1.2± .9
		March	[a] .3± .8	[a] .5± .9
		April	[b] .5± .2	[a,b] .1± .3
		May	.9± .7	[a] .6±1.3
		June	[a] 0± .5	[a] 0± .6
Idaho:	Idaho Falls	January	1.5± .6	1.9± .7
		February	.8± .6	1.4±1.2
		March	1.6± .8	3.4± .9
		April	[a] .5± .8	[a] 1.2±1.3
		May	.6± .5	[a] 1.0±1.6
		June	[a] .3± .7	1.1± .6
Ill:	Chicago	January	NS	[a] .8± .8
		February	NS	[a] .4± .8
		March	NS	1.1± .9
		April	NS	1.3± .7
		May	NS	1.6± .8
		June	NS	[a] 1.1±1.3
La:	New Orleans	January	1.2±1.0	[a] .4± .9
		February	1.0± .6	[a] .8± .9
		March	NS	[a] .2± .6
		April	[a] .2± .7	1.3± .7
		May	[a,b] .1± .2	[b] .4± .3
		June	NS	NS
Mass:	Boston	January	1.3± .6	[a] .6± .8
		February	2.6± .7	1.6± .8
		March	[a] .8± .8	1.4± .9
		April	1.9± .9	1.1±1.0
		May	1.5± .7	1.1± .7
		June	1.0± .6	1.5±1.4
Oreg:	Portland	January	[b] 1.0± .3	[a,b] .2± .3
		February	[a] .5± .8	[a] .6± .9
		March	[a] .5± .7	1.3± .7
		April	[a] .2± .6	[a] .1± .8
		May	[a] .1± .5	[a] .3± .6
		June	[a] .1± .3	[a] .4± .6
S. C:	Charleston	January	[a] .9±1.0	1.3± .9
		February	.7± .6	[a] .7± .9
		March	[a] .2± .5	.6± .5
		April	[a] .1± .6	.7± .6
		May	[a] 0± .5	[a] .2± .8
		June	NS	NS

[a] Values are not statistically significant at the 95-percent confidence level.
[b] Electrolytically enriched.
NS, no sample.

Table 3. Summary of the mean carbon-14 concentrations in total diet and milk for all stations

Date collected	Concentration (pCi/kg)	
	Total diet	Milk
July–December 1965	1,120	570
April 1966	1,100	610
October 1966	1,200	555
April 1967	1,290	680
October 1967	1,170	570
April 1968	1,160	550
October 1968	1,030	500
April 1969	1,020	500
October 1969	1,000	490
March–April 1970	890	470

Table 4. Summary of the mean tritium concentrations in total diet and milk for all stations

Date collected	Concentration[a] (nCi/kg)	
	Total diet	Milk
July–December 1965	1.49	1.28
1966	1.17	1.02
1967	.41	.41
1968	.52	.32
January–June 1969	.58	.60

[a] Zero was used for these samples with concentrations below the 2-sigma error for averaging purposes.

SECTION II. WATER

The Public Health Service, the Federal Water Quality Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	July–December 1968	August 1970
Coast Guard	January 1968–July 1969	February 1970
Interstate Carrier Drinking Water	1967–1969	December 1970
Kansas	January–December 1969	September 1970
Minnesota	January–June 1969	January 1970
North Carolina	January–December 1967	May 1969
New York	January–June 1969	June 1970
Radiostrontium in Tap Water, *HASL*	January–December 1969	July 1970
Tritium in Community Water Supplies	1969	December 1970
Tritium in Surface Waters	January–June 1970	November 1970
Washington	January–June 1969	June 1970

---

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
Fallout in the United States and Other Areas, *HASL*	**January–June 1968**	**October 1969**
Plutonium in Airborne Particulates and Precipitation, *PHS*	**April–December 1969**	**October 1970**
Surface Air Sampling, 80th Meridian Network	**January–December 1966**	**October 1970**
Tritium in Precipitation	**July–December 1969**	**July 1970**

1. Radiation Alert Network
September 1970

National Air Pollution Control Administration
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State Health Department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate National Air Pollution Control Administration officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Data Acquisition and Analysis Branch, Division of Air Quality and Emission Data, NAPCA, Cincinnati, Ohio. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique during September 1970. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

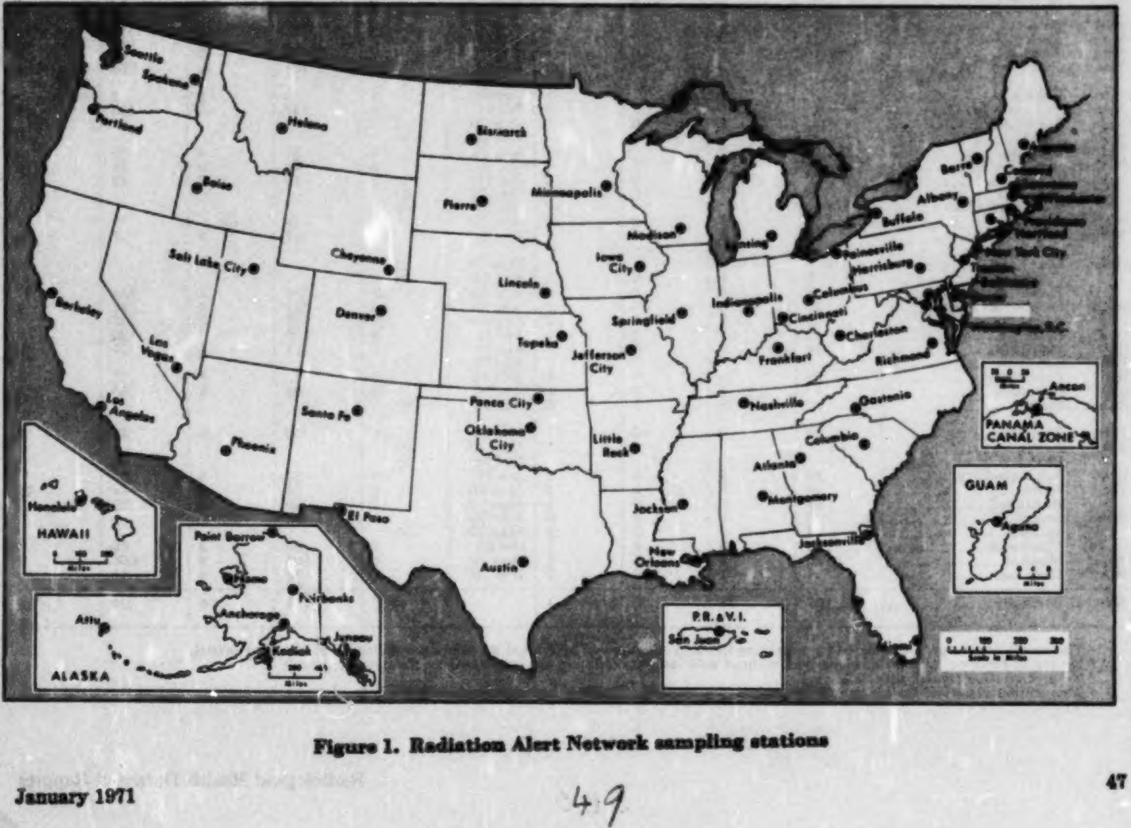

Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Salt Lake City
Cheyenne
Lincoln
Iowa City
Madison
Lansing
Buffalo
Albany
Barre
Concord
Painesville
Harrisburg
New York City
Berkeley
Denver
Columbus
Indianapolis
Springfield
Cincinnati
Charleston
Topeka
Jefferson City
Frankfort
Richmond
Washington, D.C.
Las Vegas
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Phoenix
Little Rock
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Jackson
El Paso
Austin
New Orleans
Jacksonville
Miami
Ancon
PANAMA CANAL ZONE
GUAM
Agana
HAWAII
Honolulu
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Kodiak
Juneau
ALASKA
P.R. & V.I.
San Juan
Scale in Miles

Figure 1. Radiation Alert Network sampling stations

49

Table 1. Gross beta radioactivity in surface air and precipitation, September 1970

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation				
			Maximum	Minimum	Average		Number of samples	Total depth (mm)	Field estimation of deposition		
									Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	17	4	1	3	Oct 70	1	36	1	36	0
Alaska:	Anchorage	(b)				June 70	(c)				
	Attu Island	30	0	0	0	Nov 70	(c)				
	Fairbanks	19	2	0	1	July 70	9	29	9	29	18
	Juneau	6	7	2	5	Aug 70	5	147	5	147	0
	Kodiak	1	0	0	0	Sept 70	(c)				
	Nome	14	2	0	1	Dec 70	(c)				
	Point Barrow	(b)				Dec 70	(c)				
Ariz:	Phoenix	13	7	0	4	Aug 70	(c)				
Ark:	Little Rock	(b)				June 70	(c)				
Calif:	Berkeley	18	3	0	1	Sept 70	(c)				
	Los Angeles	20	4	0	2	Jan 71	(c)				
C.Z:	Ancon	11	0	0	0	Sept 70	(c)				
Colo:	Denver	10	7	0	3	Sept 70	(c)				
Conn:	Hartford	21	2	0	1	July 70	9	71	9	71	0
Del:	Dover	21	3	0	1	May 70	(c)				
D.C:	Washington	25	1	0	0	Dec 70	(c)				
Fla:	Jacksonville	20	1	0	0	June 70	4	86	3	62	10
	Miami	10	0	0	0	July 70	8	196	8	196	0
Ga:	Atlanta	19	2	1	1	Jan 71	(c)				
Guam:	Agana	(b)				May 70	(c)				
Hawaii:	Honolulu	25	1	0	0	Nov 70	5	37	(d)		
Idaho:	Boise	21	5	0	3	Nov 70	2	22	2	22	6
Ill:	Springfield	4	5	1	2	Dec 70	(c)				
Ind:	Indianapolis	21	5	0	1	Jan 71	(c)				
Iowa:	Iowa City	20	4	0	1	Sept 70	5	154	5	154	32
Kans:	Topeka	21	3	0	1	June 70	11	161	11	161	0
Ky:	Frankfort	4	1	0	1	Dec 70	(c)				
La:	New Orleans	18	1	0	0	Aug 70	12	151	(d)		
Maine:	Augusta	20	3	0	1	Jan 71	8	79	8	79	0
Md:	Baltimore	20	1	0	1	July 70	1	3	1	3	0
Mass:	Lawrence	21	2	0	1	Sept 70	5	55	5	55	1
	Winchester	18	2	0	1	Oct 70	5	69	5	69	0
Mich:	Lansing	20	2	0	1	Nov 70	10	112	10	112	11
Minn:	Minneapolis	21	2	0	1	May 70	7	117	7	117	3
Miss:	Jackson	18	2	0	1	Aug 70	2	53	2	53	8
Mo:	Jefferson City	22	3	0	1	Jan 71	12	224	12	224	0
Mont:	Helena	20	3	1	1	Oct 70	1	3	1	3	0
Nebr:	Lincoln	16	5	0	2	Jan 71	4	133	4	133	14
Nev:	Las Vegas	21	2	0	2	July 70	(c)				
N.H:	Concord	(b)				Dec 70	(c)				
N.J:	Trenton	21	2	0	1	Aug 70	6	31	5	28	2
N.Mex:	Santa Fe	17	3	0	1	Oct 70	6	36	6	36	0
N.Y:	Albany	2	0	0	0	Jan 71	2	42	2	42	13
	Buffalo	18	1	0	1	Sept 70	(c)				
	New York City	(b)				Oct 70	(c)				
N.C:	Gastonia	17	16	2	8	Sept 70	1	10	(d)		
N.Dak:	Bismarck	20	6	0	2	Dec 70	4	47	4	47	6
Ohio:	Cincinnati	(b)				May 70	(c)				
	Columbus	5	2	0	1	Aug 70	(c)				
	Painesville	19	4	0	1	July 70	12	184	12	184	27
Okla:	Oklahoma City	20	3	0	1	Nov 70	6	242	6	242	4
	Ponca City	21	6	0	2	July 70	9	137	9	137	0
Oreg:	Portland	21	2	0	1	Apr 70	6	30	6	30	0
Pa:	Harrisburg	14	2	0	1	Apr 70	1	21	1	21	2
P.R:	San Juan	(b)				Aug 70	(c)				
R.I:	Providence	18	2	0	1	Nov 70	3	13	3	13	1
S.C:	Columbia	19	4	0	2	Oct 70	3	69	3	69	0
S.Dak:	Pierre	21	8	1	3	Aug 70	(c)				
Tenn:	Nashville	20	3	0	1	Nov 70	5	50	5	50	2
Tex:	Austin	(b)				May 70	(c)				
	El Paso	(b)				Dec 70	(c)				
Utah:	Salt Lake City	20	3	0	1	Jan 71	5	57	5	57	2
Vt:	Barre	18	2	0	1	June 70	8	74	8	74	11
Va:	Richmond	21	2	0	1	June 70	2	29	2	29	7
Wash:	Seattle	10	0	0	0	June 70	5	43	(d)		
	Spokane	14	3	0	2	May 70	(c)				
W.Va:	Charleston	21	3	0	1	Oct 70	4	66	3	62	4
Wis:	Madison	19	3	0	1	June 70	9	606	9	605	7
Wyo:	Cheyenne	21	7	0	3	July 70	4	22	4	22	4
Network summary		1,057	16	0	1		227	101	5	94	5

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.

50

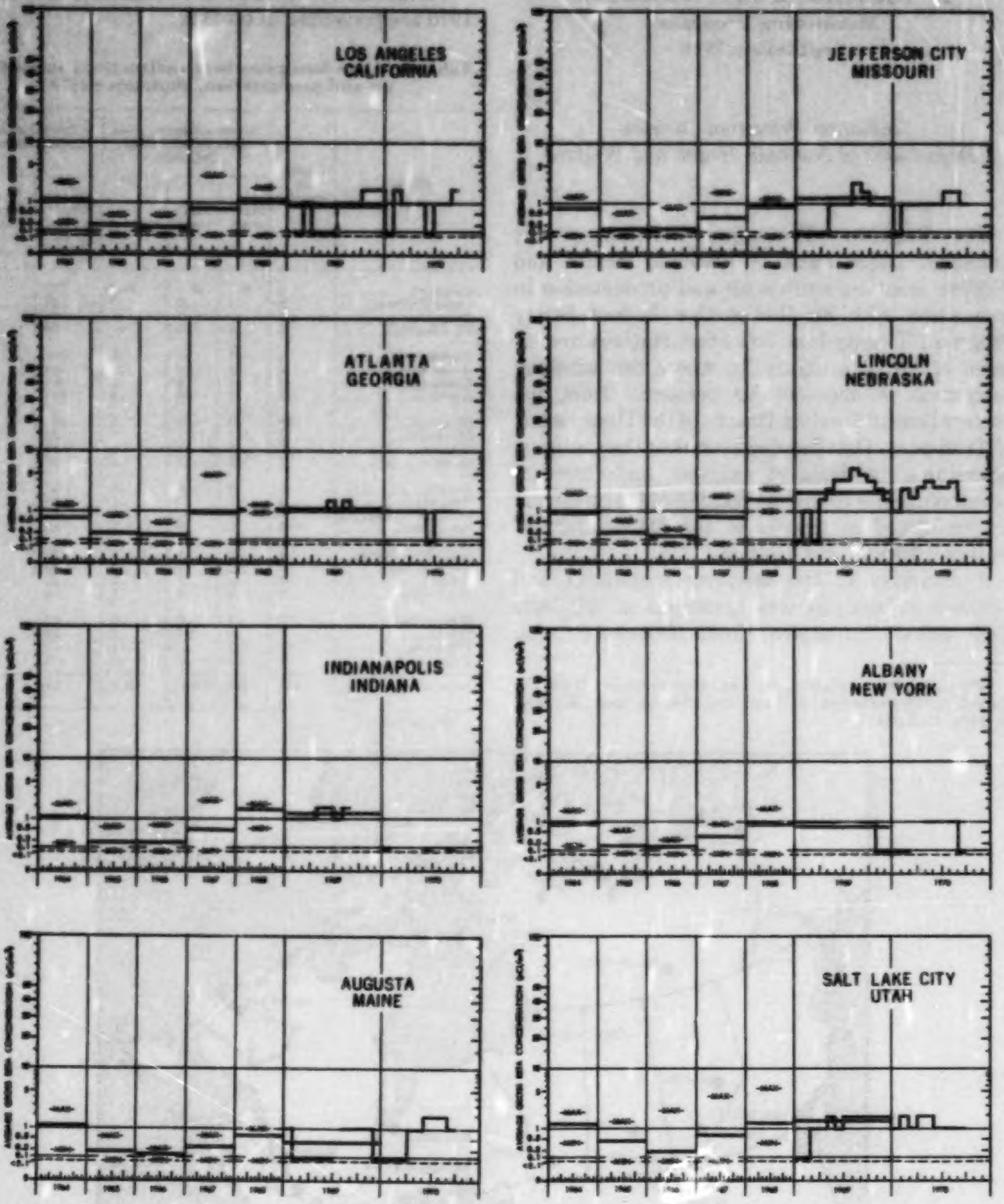


Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1964-September 1970

2. Canadian Air and Precipitation Monitoring Program[1] September 1970

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for September 1970 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, September 1970

Station	Number of samples	Air surveillance, gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	0	0	0	0	177	4.1
Coral Harbour	6	.1	.0	.0	48	2.5
Edmonton	7	.2	.1	.2	66	1.9
Ft. Churchill	5	.1	.0	.1	79	2.4
Fredericton	4	.1	.0	.1	NS	NS
Goose Bay	5	.1	.0	.1	15	1.0
Halifax	6	.1	.1	.1	31	2.4
Inuvik	5	.1	.0	.0	412	16.0
Montreal	30	.3	.0	.1	NS	NS
Moosonee	5	.1	.1	.1	27	2.8
Ottawa	7	.2	.1	.1	12	1.6
Quebec	7	.1	.0	.1	27	3.7
Regina	5	.2	.1	.1	33	2.3
Resolute	5	.1	.0	.1	39	.6
St. John's, Nfld	5	.1	.1	.1	25	2.8
Saskatoon	5	.1	.0	.1	85	.3
Sault Ste. Marie	4	.2	.1	.1	26	5.1
Thunder Bay	7	.2	.1	.1	40	3.5
Toronto	7	.3	.1	.2	25	1.3
Vancouver	5	.1	.0	.1	74	4.0
Whitehorse	7	.1	.0	.0	75	3.4
Windsor	7	.3	.1	.1	14	.8
Winnipeg	5	.1	.1	.1	46	5.3
Yellowknife	7	.1	.0	.0	33	.8
Network summary	156	0.3	0.0	0.1	64	3.2

NS, no sample.

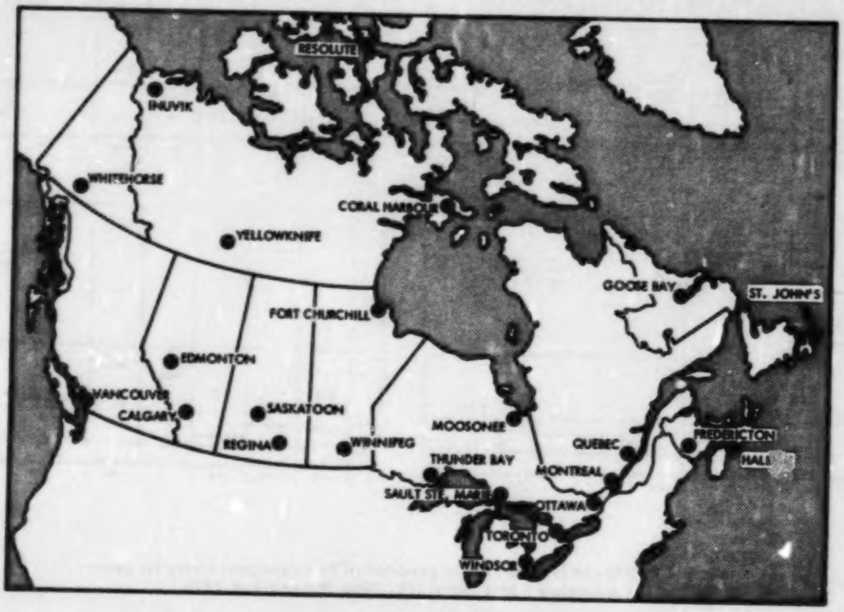

RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALI
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

---

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

52

3. Pan American Air Sampling Program September 1970

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The September 1970 air monitoring results from the participating countries are given in table 3.

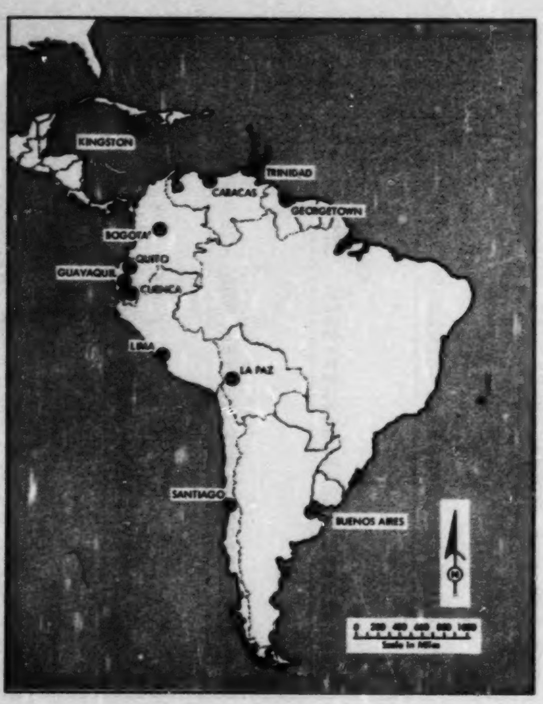


Figure 4. Pan American Air Sampling Program

Table 3. Summary of gross beta radioactivity in Pan American surface air, September 1970

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	6	0.51	0.11	0.26
Bolivia:	La Paz	17	3.05	.43	1.30
Chile:	Santiago	24	.80	.10	.32
Colombia:	Bogota	22	.26	.01	.10
Ecuador:	Cuenca	NS	NS	NS	NS
	Guayaquil	NS	NS	NS	NS
	Quito	NS	NS	NS	NS
Guyana:	Georgetown	14	.52	.05	.28
Jamaica:	Kingston	NS	NS	NS	NS
Peru:	Lima	25	1.74	.13	.94
Venezuela:	Caracas	11	.58	.04	.23
West Indies:	Trinidad	NS	NS	NS	NS
Pan American summary		119	3.05	0.01	0.52

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
NS, no sample.

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

53

Fallout in the United States and Other Areas[1] July-December 1968 and January-December 1969

Health and Safety Laboratory
U.S. Atomic Energy Commission

Monthly fallout deposition rates for strontium-90 are determined by the Health and Safety Laboratory (HASL) for 36 sites in the United States and 103 locations in other countries. HASL data from all of the active United States stations and other selected points in the Western Hemisphere (figure 1) covering the period from July–December 1968, January–December 1969 are summarized in tables 1 through 6. All the stations of the 80th Meridian Network are represented.

Methods of collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of 1 month in a stainless-steel pot with an exposed area of 0.076 m². At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with an exposed area of 0.072 m², attached to an ion exchange column. After a 1-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in

Table 1. Strontium-90 fallout in the United States, HASL, July–December 1968

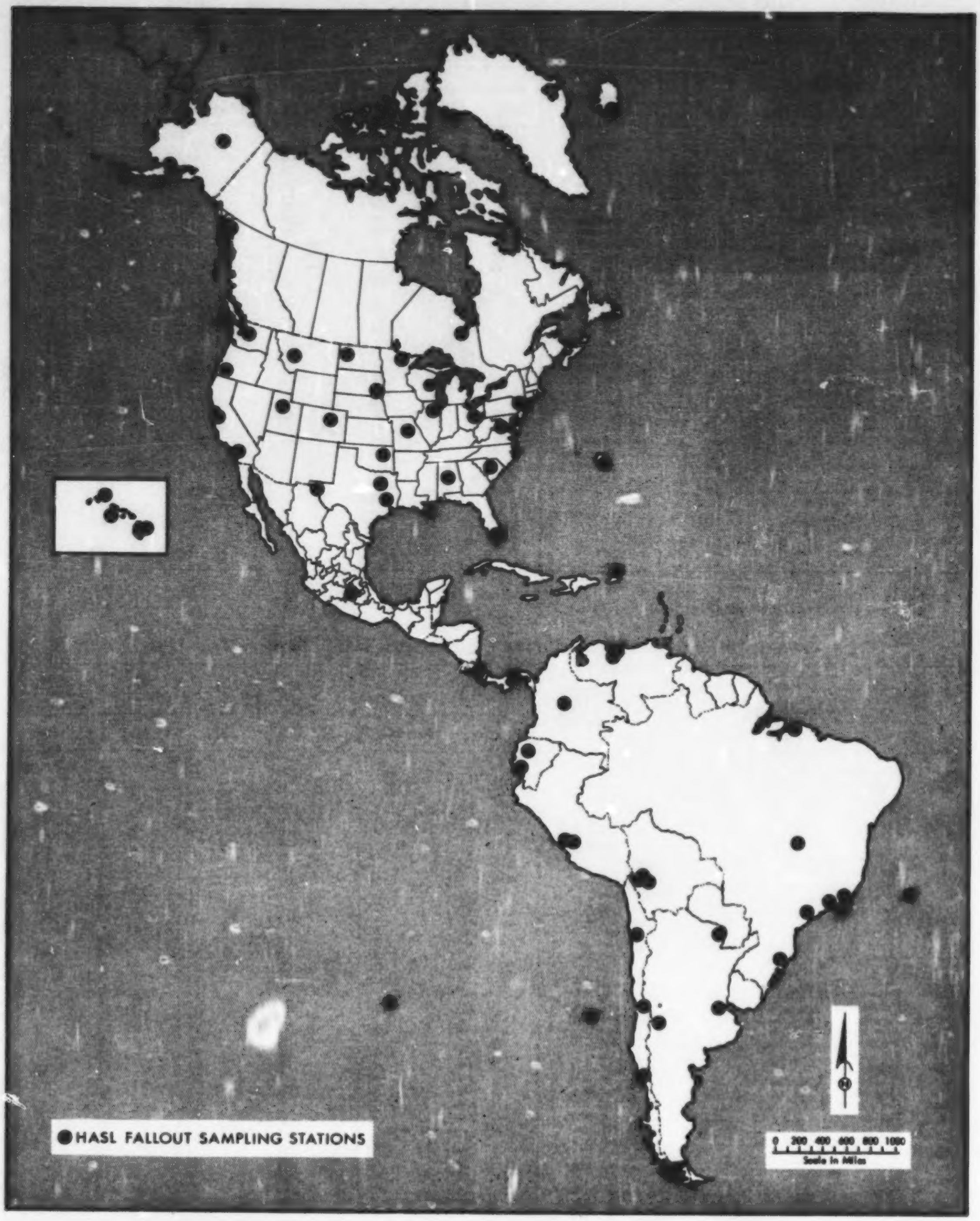
Sampling location		Type of collection	Deposition (nCi/m²)					
			July	August	September	October	November	December
Ala:	Birmingham	pot	0.24	0.09	0.06	0.02	0.08	0.06
Alaska:	Anchorage	column	.08	.02	.02	.02	(a)	(a)
	Barrow	column	.02	(a)	(a)	.01	(a)	(a)
	Cold Bay	column	.04	.09	.08	.08	.07	.03
	Fairbanks	column	.05	.07	.01	.01	(a)	.01
	Juneau	column	.12	(b)	.23	.06	.05	(a)
	Nome	column	.11	(b)	(b)	(b)	(b)	(b)
Calif:	W. Los Angeles	pot	.02	.01	(a)	.02	(a)	.04
	San Francisco	column	(a)	.02	[c].02	[c].02	(b)	.04
Colo:	Denver	column	.10	.06	.06	.05	.02	(a)
Fla:	Coral Gables	pot	[c].04	[c].04	.06	(b)	(b)	.09
	Miami	column	.12	.07	.06	.02	.01	(a)
Hawaii:	Hilo	column	[c].14	.15	.06	.04	.04	.17
	Honolulu	pot	[c].40	[c].40	[c].16	[c].16	[c].06	[c].06
	Lihue	column	.05	.04	.04	.02	.07	.05
	Mauna Loa	column	.02	.04	.04	.01	.02	(a)
Ill:	Argonne	pot	.07	.11	.09	.04	.04	.04
La:	New Orleans	column	.05	.03	.02	.02	.04	.04
Minn:	International Falls	column	.18	.07	.06	.06	(a)	(a)
Mo:	Columbia	column	.07	.05	.05	.04	.06	.06
Mont:	Helena	column	.08	.12	.08	.02	.02	(a)
N.Y.:	New York City	pot	.07	.08	.04	.06	.09	.06
N. Dak:	Williston	column	.14	.09	.03	.03	.02	(a)
Ohio:	Wooster	pot	.11	.06	.02	.03	.06	.03
Okla:	Tulsa	pot	(b)	.04	.04	.03	.07	(b)
Oreg:	Medford	column	.01	.10	.02	.02	.04	.02
S.C:	Columbia	column	.10	.02	.04	.03	.08	.02
S. Dak:	Vermillion	pot	.32	.09	.10	.09	.02	.05
Tex:	Dallas	column	.04	.03	.04	.02	.05	.02
	El Paso	column	.04	.03	.01	.02	.03	(a)
	Houston	column	.09	.04	.04	.03	(a)	.03
Utah:	Salt Lake City	pot	.03	.33	.08	.05	.12	.04
Va:	Sterling	column	.12	.06	.03	.02	.05	.02
Wash:	Seattle	pot	[c].03	[c].10	[c].10	.09	.06	.10
	Forks	column	.12	.08	.06	.25	.14	.16
Wisc:	Green Bay	column	.11	.08	.11	.03	.02	.02

[a] Zero or trace.
[b] Data not available.
[c] Proportioned from originally consolidated data.

---

[1] The data in this article were taken from "Fallout Program Quarterly Summary Report," HASL-237:A-4 to A-285. (October 1, 1970).

54



● HASL FALLOUT SAMPLING STATIONS
0 200 400 600 800 1000
Scale in Miles
N

Figure 1. HASL fallout sampling stations in the Western Hemisphere

Table 2. Strontium-90 fallout in North and South America, HASL, July–December 1968

Sampling location		Type of collection	Deposition (nCi/m²) July	August	September	October	November	December
Argentina:	Buenos Aires	column	0.02	0.19	0.04	0.21	0.21	0.23
	Formosa	column	.02	.07	.03	.09	.06	.03
	Malargue	column	(a)	(a)	.02	.02	.03	(a)
Bahamas:	Bimini	column	.08	.08	.01	(b)	(b)	(a)
Bermuda:	Kindley AFB	column	.10	.06	.05	.02	.06	.10
Bolivia:	Chacaltaya	column	.01	.09	.04	.03	.02	.07
	La Paz (city)	column	(a)	.03	.05	.05	.05	.03
	La Paz (Ovejuyo)	column	(a)	.03	.04	.04	.02	.04
Brazil:	Belem	column	(b)	(b)	(b)	(b)	(b)	(b)
	Itaici Sao Paulo	pot	(b)	(b)	(b)	(b)	(b)	(b)
	Nova Friburgo	pot	(b)	(b)	(b)	(b)	(b)	(b)
	Rio de Janeiro	column	.06	.09	.13	.10	.11	.05
	San Jose Dos Campos	pot	(b)	(b)	(b)	(b)	(b)	(b)
	Trindade Island	column	.02	.11	.08	.10	.10	.03
Canada:	Moosonee	column	.24	.27	.04	.10	.02	(a)
Canal Zone:	Balboa	column	.08	.04	.01	.02	.02	(a)
Chile:	Antofagasta	column	(b)	(b)	(b)	(b)	(b)	(b)
	Concepcion	column	.02	.13	.01	.03	.04	(a)
	Easter Island	column	.03	.04	.09	.02	.06	.02
	Puerto Montt	column	.05	[c].11	[c].12	.08	.11	.16
	Punta Arenas	column	(a)	.08	.02	(a)	.02	.04
	Santiago	pot	.01	.08	.04	(a)	(a)	(a)
	Santiago	column	(a)	.01	.05	.01	(b)	(a)
Colombia:	Bogota	pot	(a)	.01	.01	(a)	(a)	(b)
Costa Rica:	Turrialba	column	.06	.04	.03	.01	(a)	.02
Ecuador:	Guayaquil	column	(b)	(b)	(b)	(b)	(b)	(b)
	Quito	column	(b)	(b)	(b)	(b)	(b)	(b)
Greenland:	Thule	column	.02	.02	.01	(a)	(a)	(a)
Iceland:	Keflavik	column	.08	.15	.09	.04	.04	.05
Mexico:	Mexico City	column	.07	.04	.03	(a)	.02	(a)
Peru:	Lima	column	(a)	.01	.01	.01	(a)	(a)
Puerto Rico:	San Juan	column	.07	.08	.05	.02	.06	.04
Venezuela:	Caracas (site 1)	column	.05	.02	.01	.02	(a)	(a)
	Caracas (site 2)	column	(a)	.02	(b)	.01	.01	(a)

[a] Zero or trace.
[b] Data not available.
[c] Indicates proportioned from originally consolidated data.

Table 3. Strontium-90 fallout in the United States, HASL, January–June 1969

Sampling location		Type of collection	Deposition (nCi/m²) January	February	March	April	May	June
Ala:	Birmingham	pot	0.08	0.05	0.09	0.07	0.20	0.10
Alaska:	Anchorage	column	.01	(a)	(a)	(a)	.09	.02
	Barrow	column	(a)	(a)	(a)	(a)	(a)	(a)
	Cold Bay	column	.02	(a)	.03	(b)	.08	.10
	Fairbanks	column	(a)	(a)	(a)	(a)	.05	.15
	Juneau	column	.05	.11	.10	.08	(b)	.02
	Nome	column	.11	(a)	(b)	(a)	.02	.05
Calif:	W. Los Angeles	pot	.15	.14	.02	.02	.03	.01
	San Francisco	column	.09	.10	.03	.06	.01	(a)
Colo:	Denver	column	(a)	.01	.02	.08	.40	.12
Fla:	Coral Gables	pot	.03	.03	.04	.14	[c].12	[c].13
	Miami	column	.06	.03	.03	.12	.19	.18
Hawaii:	Hilo	column	.06	.41	.15	.22	(b)	(b)
	Honolulu	pot	[c].20	[c].20	(b)	(b)	(b)	.02
	Lihue	column	.06	.07	.06	.04	.06	.05
	Mauna Loa	column	.02	.02	.04	.02	.02	(a)
Ill:	Argonne	pot	.05	.01	.04	.25	.26	.18
La:	New Orleans	column	.03	.08	.07	.10	.11	.03
Minn:	International Falls	column	.02	(a)	(a)	.10	.09	.20
Mo:	Columbia	column	.06	.05	.05	.15	.26	.36
Mont:	Helena	column	.02	(a)	(a)	.06	.09	.14
N.Y:	New York City	pot	.04	.06	.16	.13	.26	.11
N. Dak:	Williston	column	(a)	(a)	(a)	.07	.09	.20
Ohio:	Wooster	pot	.04	.01	.01	.03	.05	.17
Okla:	Tulsa	pot	.09	.03	.23	.29	[c].11	[c].12
Oreg:	Medford	column	.03	.03	.01	.03	.09	.14
S.C:	Columbia	column	.02	.06	.06	(a)	.10	.18
S. Dak:	Vermillion	pot	.06	.03	.05	.15	.20	.53
Tex:	Dallas	column	.03	.03	.12	.10	.23	.05
	El Paso	column	(a)	(a)	.02	(a)	.07	(a)
	Houston	column	.03	.10	.09	.08	.09	.06
Utah:	Salt Lake City	pot	.07	.06	.12	.14	.08	.36
Va:	Sterling	column	.04	.02	.11	.07	.04	.13
Wash:	Seattle	pot	.17	.04	.05	.15	.10	.06
	Forks	column	.15	.09	.10	.22	.14	.04
Wisc:	Green Bay	column	.04	(a)	.04	.13	.08	.27

[a] Zero or trace.
[b] Data not available.
[c] Proportioned from originally consolidated data.

56

Table 4. Strontium-90 fallout in North and South America, HASL, January–June 1969

Sampling location		Type of collection	Deposition (nCi/m²)					
			January	February	March	April	May	June
Argentina:	Buenos Aires	column	0.06	0.07	0.06	0.06	0.06	0.05
	Formosa	column	(a)	.06	(b)	(b)	.03	.01
	Malargue	column	.04	.03	.02	.02	.01	.03
Bahamas:	Bimini	column	.01	.11	(a)	.04	[illegible]	.06
Bermuda:	Kindley AFB	column	.02	[c].06	[c].06	.12	.06	(b)
Bolivia:	Chacaltaya	column	.04	(a)	.03	(a)	(a)	(a)
	La Paz (city)	column	.03	.01	(a)	(a)	(a)	(a)
	La Paz (Ovejuyo)	column	.03	.03	(a)	(a)	(a)	(a)
Brazil:	Belem	column	(b)	(b)	(b)	(b)	(b)	(b)
	Rio de Janeiro	column	(b)	(b)	.06	.06	.02	.02
	Trindade Island	column	.04	(b)	.02	(b)	.04	(a)
Canada:	Moosonee	column	.03	(a)	(a)	.04	.09	.26
Canal Zone:	Balboa	column	(a)	(a)	(a)	.03	.03	.01
Chile:	Antofagasta	column	(b)	(b)	(b)	(b)	(b)	(b)
	Concepcion	column	(a)	(a)	.01	.09	.11	.18
	Easter Island	column	.05	.03	.05	.03	.06	.03
	Puerto Montt	column	.07	(b)	.07	.17	(b)	.18
	Puerta Arenas	column	.04	.07	.03	.04	.04	.07
	Santiago	pot	(a)	(a)	(a)	.02	.06	.02
	Santiago	column	.02	.01	(a)	.03	.06	.04
Colombia:	Bogota	pot	(b)	(a)	(b)	(a)	(a)	(b)
Costa Rica:	Turrialba	column	.01	(a)	.03	.03	.03	.01
Equador:	Guayaquil	column	(b)	(b)	(b)	(a)	(a)	(a)
Greenland:	Thule	column	(a)	(a)	(a)	(a)	[c].01	[c].02
Iceland:	Keflavik	column	.03	.05	.10	.08	.10	.13
Mexico:	Mexico City	column	(a)	(a)	(a)	(a)	.02	.04
Peru:	Lima	column	(a)	(a)	(a)	(a)	(a)	(a)
Puerto Rico:	San Juan	column	.06	.02	.01	.05	.06	.07
Venezuela:	Caracas (site 1)	column	(a)	(a)	(a)	.02	.01	.01
	Caracas (site 2)	column	(a)	(a)	(a)	.01	.02	(a)

[a] Zero or trace.
[b] Data not available.
[c] Proportioned from originally consolidated data.

Table 5. Strontium-90 fallout in the United States, HASL, July-December 1969

Sampling location		Type of collection	Deposition (nCi/m²)					
			July	August	September	October	November	December
Ala:	Birmingham	pot	0.09	0.04	0.02	0.03	0.01	0.06
Alaska:	Anchorage	column	.05	.04	.02	.03	.01	.01
	Barrow	column	(a)	(a)	(a)	.01	(a)	(a)
	Cold Bay	column	.08	.12	.04	.05	.02	.03
	Fairbanks	column	.06	.14	.03	.01	(a)	(a)
	Juneau	column	.12	(b)	.23	.08	.05	(a)
	Nome	column	.04	.07	(a)	.03	(a)	(a)
Calif:	W. Los Angeles	pot	.02	(b)	(a)	.01	.04	.15
	San Francisco	column	.02	(a)	(a)	.03	.01	.03
Colo:	Denver	column	.12	.03	.04	.07	.01	.01
Fla:	Coral Gables	pot	[c].08	[c].08	.01	.03	.04	.01
	Miami	column	.11	.07	.05	.05	.01	.01
Hawaii:	Hilo	column	(b)	(b)	(b)	(b)	(b)	(b)
	Honolulu	pot	.12	.12	.06	.03	.08	.04
	Lihue	column	.06	.03	(a)	.03	.01	.04
	Mauna Loa	column	(a)	(a)	.02	.01	(a)	.01
Ill:	Argonne	pot	.14	.08	.04	.07	.02	.01
La:	New Orleans	column	.16	.08	(a)	.01	.02	.04
Minn:	International Falls	column	.24	.16	.07	.06	.01	(a)
Mo:	Columbia	column	.15	.06	.06	.09	.01	.03
Mont:	Helena	column	.15	.04	(a)	.03	.01	(a)
N.Y:	New York City	pot	.26	.08	.13	.04	.06	.10
N. Dak:	Williston	column	.28	.09	.04	.03	(a)	(a)
Ohio:	Wooster	pot	.33	.11	.05	.01	.07	.03
Okla:	Tulsa	pot	(b)	.04	.04	.03	.07	(b)
Oreg:	Medford	column	.02	(a)	.02	.04	.01	.03
S.C:	Columbia	column	.06	.10	(a)	.02	.01	.06
S. Dak:	Vermillion	pot	.26	.14	.02	.06	.01	(a)
Tex:	Dallas	column	.02	.08	.02	.06	.02	.05
	El Paso	column	.10	.02	(a)	.02	(a)	.01
	Houston	column	.11	.06	.09	.03	.02	.03
Utah:	Salt Lake City	pot	.08	.05	.05	.09	.04	.06
Va:	Sterling	column	.09	.12	.05	(a)	.03	.04
Wash:	Seattle	pot	.03	.01	.08	.03	.06	.02
	Forks	column	.03	.10	.10	.13	.11	.14
Wisc:	Green Bay	column	.13	.06	.05	.06	.01	(a)

[a] Zero or trace.
[b] Data not available.
[c] Proportioned from originally consolidated data.

57

Table 6. Strontium-90 fallout in North and South America, HASL, July–December 1969

Sampling location		Type of collection	Deposition (nCi/m²)					
			July	August	September	October	November	December
Argentina:	Buenos Aires	column	0.04	(a)	0.10	0.08	0.10	0.08
	[illegible]	column	(a)	0.08	.05	.04	.06	.03
	[illegible]	column	(a)	(a)	.02	.08	.03	.12
Bahamas:	[illegible]	column	.06	(a)	(b)	.01	.02	.01
Bermuda:	Kindley AFB	column	.09	.02	.04	.08	.03	.06
Bolivia:	Chacaltaya	column	(a)	(a)	(a)	.02	.01	.02
	La Paz (city)	column	(a)	(a)	(a)	(a)	.01	.08
	La Paz (Ovejuyo)	column	.01	(a)	(a)	.01	(a)	.01
Brazil:	[illegible]	column	(b)	(b)	(b)	(b)	(b)	(b)
	Rio de Janeiro	column	.02	(b)	(b)	(b)	(b)	.13
	[illegible] Island	column	(a)	(b)	.05	.04	.08	.02
Canada:	[illegible]	column	.16	.30	.08	.04	.03	.01
Canal Zone:	[illegible]	column	.03	.04	(a)	.01	.01	(a)
Chile:	Antofagasta	column	(b)	(b)	(b)	.01	(b)	(b)
	[illegible]	column	.16	.07	.07	.07	.03	.02
	Easter Island	column	.08	.07	.07	.05	.02	.04
	Puerto Montt	column	.06	.24	.21	.10	.08	(b)
	Punta Arenas	column	(b)	.05	.06	.01	.02	(b)
	Santiago	pot	.06	.05	.03	.01	(a)	.01
	Santiago	column	.05	.05	.01	.04	.01	.01
Colombia:	[illegible]	pot	(b)	(a)	(a)	.01	(a)	(a)
Costa Rica:	Turrialba	column	.09	.02	.02	.01	.01	.02
Ecuador:	Guayaquil	column	(a)	(b)	(a)	(a)	(a)	.09
Greenland	Thule	column	[c].01	[c].02	[c].03	(a)	(a)	(a)
Iceland:	Keflavik	column	.10	.12	.03	.10	.02	.02
Mexico:	Mexico City	column	.04	(a)	.02	.01	(a)	(a)
Peru:	Lima	column	(a)	(a)	.02	.01	(a)	(a)
Puerto Rico:	San Juan	column	.08	.06	.02	.08	.06	.01
Venezuela:	Caracas (site 1)	column	.02	.01	(a)	.03	(a)	.02
	Caracas (site 2)	column	.02	(a)	(b)	(b)	(b)	(b)

[a] Zero or trace.
[b] Data not available.
[c] Proportioned from originally consolidated data.

the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95-percent confidence level there was no significant difference in the strontium-90 measurements obtained from samples collected by the two methods (*1*).

The analysis of monthly precipitation samples for other radionuclides that were being performed at laboratories in Westwood, N.J., New York City, N.Y., and Seattle, Wash., has been discontinued as of July 1967.

REFERENCE

(*1*) ONG, L. D. Y. Homogeneity between pot and ion exchange column strontium-90 measurements. Fallout Program Quarterly Summary Report, HASL-135:256–269. Office of Technical Services, Department of Commerce, Washington, D.C. (April 1, 1963).

58

Surface Air Sampling Program-80th Meridian Network[1] January-December 1967

Health and Safety Laboratory
Atomic Energy Commission

The Health and Safety Laboratory began its Surface Air Sampling Program in January 1963, as a continuation of the 80th Meridian Program conducted by the U.S. Naval Research Laboratory. The objectives of this program are to determine the concentrations of radioactivity in surface air in both hemispheres as a function of latitude and season and to interpret these data in terms of the dominant meteorological and physical processes which are operative.

The basic network consists of a line of sites approximately along the 80th Meridian extending from about 76° N to 63° S latitudes (figure 1). Since 1963, a number of sites have been added to investigate the possible effects of longitude, elevation and proximity to coastlines; and in late 1965, samplers were placed on four Atlantic Ocean weather ships to extend the surface air study over the marine environment. The Environmental Science Services Administration, Department of Commerce, maintains a collection site at the Amundson Scott Station in Antarctica. The air filter samples from this site are also included in the HASL program.

Sampling and analytical procedures

Approximately 1,400 cubic meters of ambient air per day are drawn through an 8-inch diameter microsorban filter for the land stations. For the ocean stations, about 2,200 cubic meters of air per day are filtered by an 8- by 10-inch microsorban filter. Each filter is changed on the 1st, 8th, 15th, and 22nd of the month or more frequently if the filter becomes clogged with debris suspended in the air. Under normal conditions, the filters from each station are compressed into a monthly composite and the gamma spectrum of the composite is obtained by an 8- by 4-inch NaI (Tl) crystal approximately 2 weeks after the last collection in the month.

The integrated response between 100 keV and 3.0 MeV is corrected by the average detection efficiency (35 percent) of the gamma photons present in fallout and the total gamma radioactivity is reported in units of photons/min/1,000 m^3. Average monthly gamma concentrations are calculated by weighting the concentrations in each sampling interval by the relative period of time in the interval. After the gamma measurements have been completed, monthly composites from each site are submitted to contractor laboratories for radiochemical analyses.

Since the last major nuclear weapon test series occurred at the end of 1962, only the longer lived artificially produced radionuclides were present in the filters analyzed prior to May 1966. Consequently, emphasis was given to the determination of manganese-54, iron-55, strontium-90, cadmium-109, cesium-137, cerium-144, plutonium-238, and plutonium-239. Strontium-89, zirconium-95, and cerium-141 were analyzed in samples collected after the foreign nuclear test of May 1966.

The longer lived fission products and plutonium-239 concentrations should describe the general distribution in surface air of all previous nuclear weapon debris which was transferred from the lower stratosphere to the troposphere during the collection period of this report. Other tracer radionuclides can be associated with debris from a single detonation or a series of detonations. Manganese-54 and iron-55 were produced in large quantities in the 1961 and 1962 test series. Cadmium-109 was generated by the U.S. high altitude test over Johnston Island on July 9, 1962. While plutonium-238 is present in low concentrations in nuclear weapons debris, about 17,000 curies of plutonium-238 were disseminated at high altitude in the stratosphere on April 21, 1964 during the reentry burnup of a SNAP-9A power source. As the levels of any of the radionuclides drop to

---

[1] Summarized from "Fallout Program Quarterly Summary Report," HASL 204, 237 from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

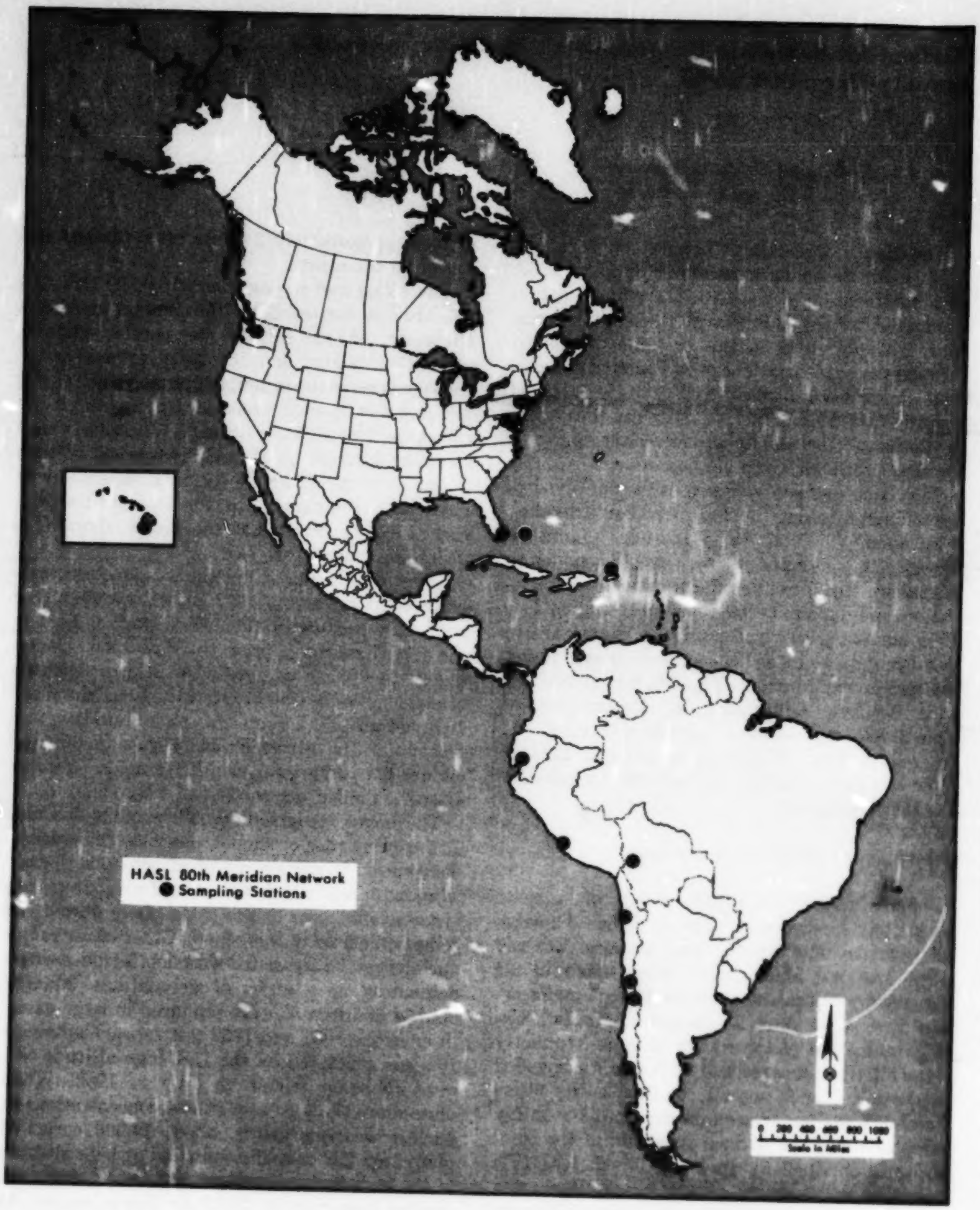

HASL 80th Meridian Network
● Sampling Stations
0 200 400 600 800 1000
Scale in Miles

Figure 1. 80th Meridian Network sampling stations

60

Table 1. Station location

Site		Latitude	Longitude (west)	Elevation (meters)
Greenland:	Thule	76° 30′ N	68° 35′	250
Ocean station:	Bravo	56° 30′ N	51° 00′	0
	Charlie	52° 45′ N	35° 30′	0
Ontario:	Moosonee	51° 16′ N	80° 30′	10
Wash:	Seattle	47° 36′ N	122° 20′	3
Ocean station:	Delta	44° 00′ N	41° 00′	0
N.J:	Westwood	41° 00′ N	74° 01′	38
N.Y:	New York	40° 48′ N	73° 58′	38
Va:	Sterling	38° 59′ N	77° 25′	76
Ocean station:	Echo	35° 00′ N	48° 00′	0
Fla:	Miami	25° 49′ N	80° 17′	4
Bahamas:	Bimini	25° 46′ N	79° 22′	3
Hawaii:	Mauna Loa	19° 28′ N	155° 36′	3,401
P.R:	San Juan	18° 30′ N	66° 00′	10
Panama:	Balboa	8° 58′ N	79° 34′	23
Ecuador:	Guayaquil	2° 10′ S	79° 52′	7
Peru:	Lima	12° 01′ S	77° 08′	13
Bolivia:	Chacaltaya	16° 21′ S	68° 07′	5,220
Chile:	Antofagasta	23° 37′ S	70° 16′	31
	Portillo	32° 50′ S	70° 08′	2,850
	Santiago	33° 27′ S	70° 42′	530
	Puerto Montt	41° 27′ S	72° 57′	7
	Punta Arenas	53° 08′ S	70° 52′	35

Table 2. Iron-55 concentrations in surface air, January-December 1967

Site		Concentration (dpm/1,000 standard m³ at midmonth)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Greenland:	Thule	50.67	63.85	75.51	79.04	17.24	18.40	104.75	[a]18.01	[a]9.23	17.95	18.14	21.44
Ocean station:	Bravo	NS	NS	26.04	49.65	25.67	NS	16.77	[a]7.00	12.84	[a]6.46	8.17	15.76
	Charlie	NS	30.88	35.45	45.73	43.40	42.64	NS	9.94	18.94	NS	[a]7.16	[a]10.37
Ontario:	Moosonee	20.34	NS	66.59	78.69	47.76	54.26	207.03	28.52	17.85	18.91	[a]10.14	13.73
Wash.:	Seattle	[a]36.52	48.15	[a]7.41	[a]37.30	78.76	58.05	37.12	NS	NS	NS	NS	NS
Ocean station:	Delta	NS	NS	51.27	56.70	67.27	56.65	26.53	19.15	26.08	20.33	19.40	10.08
N.J.:	Westwood	33.24	43.93	47.06	82.26	126.03	100.53	[a]47.94	NS	NS	NS	NS	NS
N.Y.:	New York	44.23	79.67	71.57	90.54	116.48	163.03	167.63	34.60	28.64	15.91	33.53	17.40
Va.:	Sterling	37.19	NS	NS	100.00	56.56	104.44	191.42	[a]17.48	NS	[a]26.39	[a]11.09	[a]11.75
Ocean station:	Echo	NS	39.81	55.65	200.80	47.52	76.35	43.88	[a]57.07	16.09	14.94	12.38	17.74
Fla.:	Miami	52.42	NS	84.90	179.20	75.46	36.34	202.54	15.78	[a]7.09	34.33	37.66	32.64
Bahamas:	Bimini	71.00	NS	111.38	231.92	119.48	49.73	[a]35.98	[a]15.98	(b)	[a]28.49	[a]30.30	[a]26.80
Hawaii:	Mauna Loa	106.90	NS	64.69	121.57	78.73	60.88	44.03	15.71	[a]28.40	[a]13.20	21.57	22.27
P.R.:	San Juan	31.19	31.04	77.17	116.26	36.95	17.78	[a]17.83	[a]30.96	[a]20.38	[a]9.60	[a]20.16	[a]17.22
Panama:	Balboa	22.92	NS	51.27	35.66	48.77	[a]4.85	[a]5.29	[a]5.36	[a]8.31	(b)	[a]23.04	[a]4.58
Ecuador:	Guayaquil	[a]9.07	NS	11.73	7.03	6.83	[a]5.61	[a]10.50	(b)	(b)	(b)	(b)	(b)
Peru:	Lima	32.45	NS	13.68	11.49	26.28	12.39	(b)	[a]21.32	[a]25.90	[a]63.59	[a]22.02	(b)
Bolivia:	Chacaltaya	11.32	NS	5.23	9.74	7.67	11.76	19.94	29.02	17.35	23.18	30.71	(b)
Chile:	Antofagasta	42.33	NS	14.35	13.97	10.65	62.53	[a]25.48	[a]19.78	24.97	33.73	[a]17.30	[a]20.51
	Portillo	64.10	NS	59.52	40.48	30.83	NS	NS	NS	NS	NS	NS	NS
	Santiago	[a]42.77	[a]58.86	26.85	31.92	13.21	38.69	(b)	[a]18.55	[a]13.76	(b)	(b)	(b)
	Puerto Montt	NS	35.23	42.52	18.29	24.77	[a]6.12	[a]14.62	[a]6.59	[a]7.68	[a]13.66	[a]9.11	[a]9.44
	Punta Arenas	[a]11.58	NS	42.79	11.59	10.32	6.16	[a]5.03	[a]5.12	[a]39.07	(b)	(b)	(b)

Errors are less than 20 percent except:
[a] Error between 20–100 percent.
[b] Error greater than 100 percent.
NS, no sample.

below practical determination limits, they are eliminated from the radiochemical program; thus cadmium-109 was not analyzed after the end of 1967. Manganese-54 and cesium-137 were not analyzed for 1967.

During 1966, Food Chemical and Research Laboratories, Incorporated (FCRL) of Seattle, Wash., performed the analyses of most of the samples in this program. Isotopes, Incorporated of Westwood, N.J., analyzed most of the samples collected at Westwood, N.J., and a few samples from Chacaltaya, Bolivia, Antofagasta and Santiago, Chile. Since the beginning of 1967 the analyses were contracted as follows: January and February, 1967, Tracerlab, Inc., Richmond, Calif.; March and April 1967, Custom Nuclear Co., Stanford, Calif.; May and June, 1967, Isotopes, Inc., Palo Alto, Calif.; July through December, 1967, Tracerlab Inc., Richmond, Calif.

Table 3. Strontium-89 concentrations in surface air, January–December 1967

Site		Concentration (dpm/1,000 standard m³ at midmonth)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Greenland:	Thule	93.63	55.16	[a]66.33	[a]60.60	88.94	(b)	(b)	(b)	(b)	(b)	[a]6.54	[a]3.65
Ocean station:	Bravo	12.35	NS	[a]25.64	[a]22.38	18.33	NS	[a]1.09	(b)	[a]1.80	[a]1.49	[a].53	5.56
	Charlie	NS	NS	[a]28.25	[a]30.49	37.94	15.93	NS	[a]0.72	[a].75	NS	[a]1.14	NS
Ontario:	Moosonee	27.93	37.41	[a]45.02	[a]53.86	104.24	22.74	(b)	(b)	(b)	[a]2.31	[a]7.13	[a]1.90
Wash.:	Seattle	40.05	39.66	29.10	71.06	86.83	14.91	[a]2.07	NS	NS	NS	NS	NS
Ocean station:	Delta	29.25	44.44	[a]31.75	[a]42.06	44.74	13.19	[a]1.80	(b)	[a]1.91	[a]1.56	[a]2.12	NS
N.J.:	Westwood	NS	NS	NS	NS	80.29	9.66	[a]1.65	NS	NS	NS	NS	NS
N.Y.:	New York	46.89	63.79	86.53	72.94	82.27	22.06	0.99	1.40	1.78	2.25	3.09	9.45
Va.:	Sterling	51.25	45.50	60.41	[a]98.32	40.72	38.32	(b)	(b)	[a]1.01	(b)	[a]5.92	[a]3.17
Ocean station:	Echo	65.29	52.23	[a]58.30	[a]104.42	33.06	6.63	[a]2.41	[a]3.78	[a]1.46	[a].90	[a]1.47	[a]2.35
Fla.:	Miami	17.06	90.08	[a]116.34	[a]107.14	133.25	(b)	(b)	[a]3.14	[a]1.44	[a]1.20	[a]30.57	3.97
Bahamas:	Bimini	73.50	NS	[a]100.27	[a]98.87	NS	8.69	3.37	[a]1.55	(b)	[a]3.45	[a]5.79	5.79
Hawaii:	Mauna Loa	300.66	110.88	[a]52.81	[a]63.09	30.70	18.81	18.68	NS	[a]3.41	[a]2.15	[a]56.62	[a]4.60
P.R.:	San Juan	8.89	NS	[a]89.33	[a]93.60	42.61	(b)	[a]2.23	[a]1.80	[a]1.04	[a]2.33	[a]1.54	[a]2.99
Panama:	Balboa	6.97	NS	[a]53.52	[a]25.84	24.00	NS	4.66	5.13	[a]1.48	[a].80	[a]17.80	[a]1.31
Ecuador:	Guayaquil	5.01	NS	(b)	(b)	(b)	NS	78.30	19.88	(b)	4.66	5.48	[a]1.55
Peru:	Lima	[a]20.24	NS	(b)	(b)	(b)	NS	172.89	NS	37.18	21.12	6.45	[a]2.24
Bolivia:	Chacaltaya	13.48	42.64	(b)	(b)	(b)	120.61	284.95	252.55	36.59	13.30	[a]2.00	[a].33
Chile:	Antofagasta	NS	12.65	(b)	(b)	(b)	28.71	234.33	75.52	25.28	[a]12.50	[a]6.60	(b)
	Portillo	57.05	NS	(b)	(b)	54.39	NS	NS	NS	NS	NS	NS	NS
	Santiago	23.08	NS	[a]24.60	(b)	(b)	15.26	40.63	61.80	30.39	15.03	6.96	[a]8.43
	Puerto Montt	20.16	NS	(b)	(b)	(b)	9.26	19.45	16.03	10.52	6.74	[a]5.38	[a]2.81
	Punta Arenas	[a]3.53	NS	[a]18.02	(b)	(b)	4.51	1.10	5.76	[a]6.22	3.09	[a]2.46	2.01

Errors are less than 20 percent except:
[a] error between 20–100 percent.
[b] error greater than 100 percent.
NS, no sample.

Results

The updated radioactivity concentrations in surface air during 1967 are presented in tables 2 through 10. The sites are listed according to latitude beginning with the most northern site at Thule, Greenland (table 1). The results of the blank and standard analyses are reported in tables 11 through 13.

The concentrations are reported at the midpoint of the collection month for the plutonium isotopes and the fission products and on the following dates

Table 4. Strontium-90 concentration in surface air, January–December 1967

Site		Concentration (dpm/1,000 standard m³ at midmonth)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Greenland:	Thule	5.98	7.00	8.93	8.70	5.17	2.00	1.83	1.60	0.94	0.86	[a]0.75	1.96
Ocean station:	Bravo	1.37	NS	2.61	2.98	2.75	3.26	1.73	1.03	1.11	.79	.57	1.54
	Charlie	NS	NS	2.94	4.16	4.34	2.49	NS	1.12	1.12	1.07	.88	1.50
Ontario:	Moosonee	2.21	5.08	6.87	8.06	6.42	5.22	3.79	3.09	2.43	[a]1.62	[a]1.60	.75
Wash.:	Seattle	2.90	4.13	5.92	7.62	6.72	4.46	3.91	NS	NS	NS	NS	NS
Ocean station:	Delta	4.02	3.90	3.52	5.19	[a]6.50	4.20	2.68	2.24	3.53	1.88	1.39	1.40
N.J.:	Westwood	3.72	6.97	6.50	11.26	9.73	6.70	4.61	NS	NS	NS	NS	NS
N.Y.:	New York	4.19	7.60	6.66	7.61	8.51	7.61	4.00	3.39	3.21	2.43	1.06	1.04
Va.:	Sterling	4.13	5.57	4.66	10.55	6.65	6.31	3.75	2.58	2.10	1.12	(b)	1.43
Ocean station:	Echo	5.36	4.43	4.95	15.86	4.83	5.77	4.51	1.99	1.89	1.71	1.28	.92
Fla.:	Miami	1.71	7.98	8.96	15.31	6.78	1.92	3.44	1.61	1.09	1.53	(b)	2.41
Bahamas:	Bimini	6.27	NS	11.46	17.91	NS	3.32	4.21	1.60	1.59	2.48	2.74	2.86
Hawaii:	Mauna Loa	10.79	11.23	6.50	11.31	5.52	3.61	2.82	NS	1.39	1.36	[a]7.68	1.97
P.R.:	San Juan	1.95	NS	7.17	10.27	4.19	2.10	3.45	2.47	.91	.82	.89	2.26
Panama:	Balboa	1.97	NS	5.32	3.18	3.11	NS	1.26	.72	.22	.15	[a]1.98	.76
Ecuador:	Guayaquil	.59	NS	1.06	.55	.59	NS	[a]1.02	.63	[a].04	.63	1.61	1.02
Peru:	Lima	3.14	NS	1.56	.93	1.85	NS	2.46	NS	2.87	3.22	1.77	1.43
Bolivia:	Chacaltaya	1.74	4.08	.25	.95	.70	2.88	3.63	5.37	2.02	2.63	1.89	.98
Chile:	Antofagasta	NS	3.28	1.60	NS	1.61	8.27	4.17	3.57	2.29	[a]2.32	2.26	2.56
	Portillo	7.47	NS	2.60	2.60	3.97	NS	NS	NS	NS	NS	NS	NS
	Santiago	3.57	NS	2.52	1.38	1.60	4.38	2.58	3.16	3.37	2.49	2.53	[a]1.89
	Puerto Montt	2.87	NS	2.26	1.84	1.06	1.07	2.00	1.15	.88	1.13	1.16	1.67
	Punta Arenas	2.08	NS	2.00	.99	.95	.56	.70	.66	[a].47	.82	.65	.95

Errors are less than 20 percent except:
[a] error between 20–100 percent.
[b] error greater than 100 percent.
NS, no sample.

Table 5. Zirconium-95 concentrations in surface air, January–December 1967

Site		Concentration (dpm/1,000 standard m³ at midmonth) Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Greenland:	Thule	NS	44.13	(b)	(b)	(b)	2.03	(b)	26.56	[a]0.46	6.09	9.77	22.97
Ocean station:	Bravo	9.34	NS	(b)	(b)	2.77	2.67	[a]0.30	[a].12	9.03	8.28	11.42	14.55
	Charlie	NS	NS	(b)	(b)	3.54	2.55	NS	[a].17	3.52	NS	8.62	14.63
Ontario:	Moosonee	NS	NS	(b)	(b)	3.01	2.90	(b)	2.80	3.94	12.17	5.54	14.60
Wash.:	Seattle	30.96	27.25	27.30	19.08	4.57	4.17	[a].74	NS	NS	NS	NS	NS
Ocean station:	Delta	NS	23.54	(b)	(b)	4.95	3.47	.65	24.22	18.88	30.53	16.59	23.09
N.J.:	Westwood	NS	NS	NS	NS	7.30	7.23	[a].99	NS	NS	NS	NS	NS
N.Y.:	New York	NS	47.00	11.41	12.43	6.38	8.42	1.91	1.45	22.36	.18	16.32	92.78
Va.:	Sterling	NS	30.25	NS	(b)	7.01	7.32	(b)	[a]1.50	4.07	13.58	18.63	18.82
Ocean station:	Echo	34.94	NS	(b)	(b)	2.85	5.50	1.53	[a]1.88	21.28	19.63	11.68	19.59
Fla.:	Miami	NS	NS	(b)	(b)	5.44	1.86	(b)	3.63	5.94	25.64	36.79	34.73
Bahamas:	Bimini	184.25	NS	(b)	(b)	7.16	2.67	4.66	7.62	5.50	35.62	35.26	41.56
Hawaii:	Mauna Loa	NS	NS	(b)	(b)	3.46	3.54	(b)	32.94	14.10	12.09	29.56	28.81
P.R.:	San Juan	9.08	NS	(b)	(b)	3.57	2.34	3.02	3.40	7.92	8.91	12.53	24.07
Panama:	Balboa	NS	15.20	(b)	(b)	3.48	1.16	9.03	9.78	4.21	[a]1.43	3.43	8.51
Ecuador:	Guayaquil	NS	5.35	(b)	(b)	(b)	4.51	149.80	58.98	52.10	21.07	17.28	10.17
Peru:	Lima	NS	NS	(b)	(b)	(b)	10.37	380.35	NS	80.51	57.86	22.09	14.82
Bolivia:	Chacaltaya	20.74	3.33	(b)	(b)	(b)	22.65	447.65	506.57	101.26	35.67	12.16	[a]2.58
Chile:	Antofagasta	NS	NS	(b)	(b)	1.63	5.45	462.59	178.15	85.03	37.05	(b)	(b)
	Portillo	NS	NS	(b)	(b)	2.13	NS	NS	NS	NS	NS	NS	NS
	Santiago	NS	NS	(b)	(b)	(b)	5.84	80.17	NS	82.35	[a]1.72	22.91	9.87
	Puerto Montt	NS	19.74	(b)	(b)	.91	3.94	35.80	32.05	25.35	17.44	10.41	7.00
	Punta Arenas	17.78	8.50	(b)	(b)	.81	(b)	2.51	12.62	11.65	9.37	4.85	4.72

Errors are less than 20 percent except:
[a] error between 20–100 percent.
[b] error greater than 100 percent.
NS, no sample.

Table 6. Cadmium-109 concentrations in surface air, January–December 1967

Site		Concentration (dpm/1,000 standard m³ at midmonth) ×100 Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Greenland:	Thule	(b)	(b)	(b)	(b)	[a]26.44	(b)	(b)	(b)	(b)	[a]52.14	(b)	NS
Ocean station:	Bravo	(b)	(b)	(b)	(b)	(b)	NS	(b)	(b)	(b)	(b)	(b)	NS
	Charlie	NS	(b)	(b)	(b)	NA	(b)	NS	(b)	(b)	NS	(b)	NS
Ontario:	Moosonee	(b)	[a]44.71	(b)	[a]60.89	52.94	(b)	(b)	(b)	(b)	(b)	(b)	NS
Wash.:	Seattle	(b)	NS	(b)	[a]57.57	[a]25.81	(b)	(b)	NS	NS	NS	NS	NS
Ocean station:	Delta	(b)	(b)	(b)	(b)	NS	[a]12.39	(b)	(b)	(b)	(b)	(b)	NS
N.J.:	Westwood	[a]54.44	(b)	(b)	(b)	[a]29.44	(b)	(b)	NS	NS	NS	NS	NS
N.Y.:	New York	NS	NS	9.56	24.82	NS	61.88	9.77	34.89	36.94	NS	12.37	NS
Va.:	Sterling	(b)	(b)	(b)	[a]26.38	NS	(b)	(b)	(b)	(b)	(b)	(b)	NS
Ocean station:	Echo	(b)	(b)	(b)	(b)	NS	[a]19.13	(b)	(b)	(b)	(b)	(b)	NS
Fla.:	Miami	(b)	(b)	(b)	[a]38.10	(b)	(b)	(b)	(b)	(b)	(b)	(b)	NS
Bahamas:	Bimini	(b)	(b)	(b)	70.62	(b)	(b)	(b)	(b)	(b)	(b)	(b)	NS
Hawaii:	Mauna Loa	(b)	(b)	(b)	(b)	NS	[a]13.61	(b)	(b)	(b)	(b)	(b)	NS
P.R.:	San Juan	(b)	(b)	(b)	[a]32.02	[a]16.01	(b)	(b)	(b)	(b)	[a]64.41	(b)	NS
Panama:	Balboa	(b)	(b)	(b)	(b)	NS	(b)	(b)	(b)	(b)	NS	(b)	NS
Ecuador:	Guayaquil	(b)	(b)	(b)	(b)	43.38	(b)	(b)	(b)	(b)	NS	(b)	NS
Peru:	Lima	(b)	(b)	(b)	(b)	NS	(b)	(b)	(b)	(b)	NS	(b)	NS
Bolivia:	Chacaltaya	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	NS
Chile:	Antofagasta	(b)	(b)	(b)	(b)	NS	(b)	(b)	(b)	NS	(b)	(b)	NS
	Portillo	(b)	(b)	(b)	(b)	97.07	NS	NS	NS	NS	NS	NS	NS
	Santiago	(b)	(b)	(b)	(b)	NS	(b)	(b)	NS	(b)	(b)	(b)	NS
	Puerto Montt	(b)	(b)	(b)	(b)	(b)	NS	(b)	(b)	(b)	(b)	(b)	NS
	Punta Arenas	(b)	(b)	[a]24.77	(b)	[a]14.50	(b)	(b)	(b)	(b)	(b)	(b)	NS

Errors are less than 20 percent except:
[a] error between 20–100 percent.
[b] error greater than 100 percent.
NS, no sample.

for the induced nuclides:

Manganese-54 and iron-55	October 15, 1961
Cadmium-109	July 9, 1962

One standard deviation of the counting error for these data is always less than ±20 percent unless otherwise indicated.

Data reliability

The quality of the radiochemical analysis is monitored through the use of various "knowns" submitted to the contractor each month along

Table 7. Cerium-141 concentrations in surface air, January-December 1967

Site	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Concentration (dpm/1,000 standard m^3 at midmonth)											
Greenland: Thule	460.82	105.87	(b)	(b)	(b)	(b)	(b)	[a]4.19	NS	NS	NS	[a]13.04
Ocean station: Bravo	[a]11.64	[a]42.60	(b)	(b)	(b)	(b)	(b)	(b)	NS	NS	NS	(b)
Charlie	NS	76.14	(b)	(b)	(b)	(b)	NS	(b)	NS	NS	NS	NS
Ontario: Moosonee	(b)	[a]72.71	(b)	(b)	(b)	(b)	(b)	[a]3.78	NS	NS	NS	[a]9.93
Wash.: Seattle	(b)	(b)	(b)	[a]195.41	(b)	(b)	[a]3.01	NS	NS	NS	NS	NS
Ocean station: Delta	129.83	[a]48.79	(b)	(b)	(b)	(b)	[a]3.03	(b)	NS	NS	NS	NS
N.J.: Westwood	NS	NS	NS	NS	(b)	(b)	[a]3.96	NS	NS	NS	NS	NS
N.Y.: New York	336.23	96.33	NS	NS	NS	NS	1.11	20.47	NS	NS	NS	115.53
Va.: Sterling	172.79	[a]40.86	[a]33.48	(b)	(b)	(b)	(b)	[a]3.03	NS	NS	NS	(b)
Ocean station: Echo	74.48	[a]59.42	(b)	(b)	(b)	(b)	[a]3.51	NS	NS	NS	NS	[a]6.99
Fla.: Miami	243.96	[a]54.23	(b)	(b)	(b)	(b)	(b)	(b)	NS	NS	NS	[a]9.61
Bahamas: Bimini	400.00	[a]121.80	(b)	(b)	(b)	(b)	[a]4.08	[a]9.75	NS	NS	NS	[a]42.54
Hawaii: Mauna Loa	[a]306.55	98.60	(b)	(b)	(b)	(b)	(b)	[a]9.56	NS	NS	NS	(b)
P.R.: San Juan	48.02	[a]37.40	(b)	(b)	(b)	(b)	(b)	(b)	NS	NS	NS	[a]63.07
Panama: Balboa	[a]23.63	[a]30.62	(b)	(b)	(b)	(b)	16.14	[a]12.80	NS	NS	NS	[a]14.31
Ecuador: Guayaquil	[a]16.31	[a]8.50	(b)	(b)	(b)	(b)	279.47	96.07	NS	NS	NS	(b)
Peru: Lima	[a]110.89	[a]27.14	(b)	(b)	(b)	(b)	690.30	[a]86.51	NS	NS	NS	[a]15.90
Bolivia: Chacaltaya	[a]21.69	(b)	(b)	(b)	(b)	(b)	731.05	656.76	NS	NS	NS	(b)
Chile: Antofagasta	[a]61.16	[a]56.08	(b)	(b)	(b)	NS	999.51	234.51	NS	NS	NS	[a]11.66
Portillo	[a]258.01	[a]26.53	(b)	(b)	(b)	(b)	NS	NS	NS	NS	NS	NS
Santiago	[a]79.38	[a]78.60	(b)	(b)	(b)	(b)	133.67	155.40	NS	NS	NS	[a]12.86
Puerto Montt	[a]69.57	(b)	(b)	(b)	(b)	(b)	63.13	41.33	NS	NS	NS	(b)
Punta Arenas	[a]107.41	[a]20.79	(b)	(b)	(b)	(b)	[a]3.46	[a]13.19	NS	NS	NS	[a]10.70

Errors are less than 20 percent except:
[a] error between 20–100 percent.
[b] error greater than 100 percent.
NS, no sample.

Table 8. Cerium-144 concentrations in surface air, January-December 1967

Site	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Concentration (dpm/1,000 standard m^3 at midmonth)											
Greenland: Thule	57.14	21.06	22.58	22.05	8.61	3.76	1.54	3.57	0.67	3.25	6.82	17.09
Ocean station: Bravo	3.63	10.73	7.61	7.90	4.93	4.49	1.29	.79	3.80	3.29	5.78	7.97
Charlie	NS	8.99	11.79	10.78	7.44	3.64	NS	.72	2.52	[a]3.12	3.94	10.89
Ontario: Moosonee	6.41	13.65	23.08	23.35	12.16	8.76	2.88	3.05	2.88	5.93	4.69	9.04
Wash.: Seattle	12.67	11.67	16.46	13.41	10.10	4.27	3.12	NS	NS	NS	NS	NS
Ocean station: Delta	11.66	11.11	15.67	12.04	10.86	5.36	[a]2.07	5.69	8.02	8.33	11.55	16.06
N.J.: Westwood	17.22	18.84	18.61	21.30	13.46	8.18	3.21	NS	NS	NS	NS	NS
N.Y.: New York	31.54	22.98	17.91	28.85	14.18	16.31	3.70	4.67	10.28	8.55	9.82	39.27
Va.: Sterling	28.57	15.43	19.07	23.36	12.53	8.36	3.02	2.10	3.16	6.76	9.88	12.45
Ocean station: Echo	15.15	11.75	16.25	30.80	8.37	6.54	3.36	1.81	6.71	10.42	7.86	15.24
Fla.: Miami	36.47	24.02	22.70	46.19	12.61	2.63	4.06	2.54	2.36	11.55	21.11	24.86
Bahamas: Bimini	53.75	30.79	33.88	90.66	40.60	3.93	4.43	4.29	3.05	14.44	21.07	30.10
Hawaii: Mauna Loa	50.60	20.77	10.66	16.41	6.76	4.83	5.09	4.07	7.41	7.23	17.87	22.30
P.R.: San Juan	5.84	7.79	16.80	21.90	6.87	3.97	3.08	2.90	3.97	5.12	6.81	18.28
Panama: Balboa	4.80	8.82	10.87	5.89	3.32	.37	3.16	4.04	1.76	.86	2.10	6.41
Ecuador: Guayaquil	6.61	3.63	2.79	1.48	.92	7.08	36.53	21.03	18.25	11.85	13.08	5.94
Peru: Lima	35.88	11.42	6.11	2.87	3.10	20.88	98.38	41.11	35.90	34.91	17.98	7.77
Bolivia: Chacaltaya	11.91	3.00	.00	1.72	1.10	56.24	105.31	170.47	42.89	17.60	8.01	2.73
Chile: Antofagasta	26.05	16.30	5.80	3.60	3.37	11.80	117.95	64.18	34.52	21.85	15.33	8.82
Portillo	54.49	17.18	7.82	8.50	6.82	NS	NS	NS	NS	NS	NS	NS
Santiago	40.31	27.73	10.46	14.42	3.09	8.83	22.60	42.42	36.24	23.88	30.23	13.19
Puerto Montt	18.80	18.08	7.62	4.47	2.34	2.19	10.31	10.93	10.52	9.28	7.89	7.44
Punta Arenas	10.60	6.73	7.18	4.08	1.55	1.23	1.26	4.80	5.11	5.96	3.79	4.37

[a] Errors are less than 20 percent except error between 20–100 percent.
NS, no sample.

Table 9. Plutonium-238 concentrations in surface air, January–December 1967

Site		Concentration (dpm/1,000 standard m^3 at midmonth) ×100											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Greenland:	Thule	1.26	2.31	4.06	4.03	2.86	2.94	1.64	[a]1.94	[a]0.66	[a]1.93	[a]1.05	2.09
Ocean station:	Bravo	[a].30	1.62	1.17	2.04	1.73	NS	[a]1.58	1.14	1.29	1.45	.60	.90
	Charlie	NS	[a]1.44	1.74	2.91	2.47	NS	NS	1.30	1.38	3.06	.59	1.73
Ontario:	Moosonee	1.04	2.28	2.37	4.15	4.94	6.95	3.72	2.81	2.38	2.06	NS	1.07
Wash.:	Seattle	(b)	[a].45	(b)	(b)	NS	NS	4.64	NS	NS	NS	NS	NS
Ocean station:	Delta	1.53	1.72	3.02	3.63	4.68	NS	3.49	NS	(b)	(b)	1.82	2.45
N.J.:	Westwood	4.07	4.86	3.93	6.14	NS	NS	3.32	NS	NS	NS	NS	NS
N.Y.:	New York	1.91	3.02	3.41	5.12	4.80	18.00	5.52	5.31	3.63	2.78	2.24	4.79
Va.:	Sterling	1.47	3.03	3.05	6.58	7.33	8.18	4.92	2.47	2.51	1.33	1.89	1.41
Ocean station:	Echo	2.94	2.04	3.53	11.41	5.32	NS	4.03	2.17	[a]1.82	2.27	1.87	2.45
Fla.:	Miami	2.30	2.92	5.93	11.57	8.36	3.36	3.61	2.03	1.17	2.22	3.06	NS
Bahamas:	Bimini	3.75	6.06	7.89	15.56	8.37	NS	4.22	2.70	1.66	2.67	4.74	3.80
Hawaii:	Mauna Loa	5.03	4.95	5.51	8.73	6.22	6.09	NS	2.16	1.75	1.31	NS	1.74
P.R.:	San Juan	[a]1.90	2.34	5.24	7.12	4.21	4.49	3.81	2.14	[a]1.16	[a].77	[a]1.80	2.02
Panama:	Balboa	[a]1.44	2.35	5.32	3.00	2.57	.88	1.12	[a].66	[a].41	(b)	[a].37	[a].86
Ecuador:	Guayaquil	[a]2.96	3.50	4.44	2.63	2.51	3.56	3.30	[a]1.98	4.36	(b)	8.90	4.56
Peru:	Lima	17.70	15.72	8.06	5.56	.51	[a]6.73	8.38	10.00	10.97	14.64	10.86	7.48
Bolivia:	Chacaltaya	5.17	2.93	1.58	4.27	2.36	10.81	5.55	13.06	5.52	5.93	[a]5.80	3.53
Chile:	Antofagasta	19.09	13.47	8.19	7.57	5.96	16.74	11.73	13.15	8.66	11.02	11.01	9.60
	Portillo	20.19	21.26	13.37	13.61	17.53	NS	NS	NS	NS	NS	NS	NS
	Santiago	21.78	[a]16.72	18.89	14.23	6.30	17.06	10.85	8.56	10.67	12.15	12.58	10.75
	Puerto Montt	10.96	13.52	11.66	10.07	6.57	NS	7.60	4.34	2.94	4.15	NS	5.60
	Punta Arenas	7.70	7.14	8.60	5.49	4.26	NS	2.29	2.54	3.04	[a]2.36	[a]2.18	4.48

Errors are less than 20 percent except:

[a] error between 20–100 percent.

[b] error greater than 100 percent.

NS, no sample.

Table 10. Plutonium-239 concentrations in surface air, January–December 1967

Site		Concentration (dpm/1,000 standard m^3 at midmonth) ×100											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Greenland:	Thule	9.11	10.00	13.72	14.27	7.74	NS	5.27	3.08	1.56	[a]1.70	2.19	4.32
Ocean station:	Bravo	1.92	5.09	3.97	5.68	5.07	NS	2.57	1.72	2.13	1.14	1.03	1.72
	Charlie	NS	5.75	5.60	7.65	6.25	NS	NS	1.95	2.06	3.83	1.16	2.63
Ontario:	Moosonee	3.38	7.60	10.28	11.36	12.45	13.95	6.89	4.84	4.53	2.79	NS	2.39
Wash.:	Seattle	[a]5.42	8.57	[a]6.78	6.89	NS	NS	6.97	NS	NS	NS	NS	NS
Ocean station:	Delta	6.23	5.76	8.14	9.06	11.85	NS	4.42	5.20	6.12	[a]2.97	NS	NS
N.J.:	Westwood	4.64	9.10	9.04	14.68	NS	NS	7.28	NS	NS	NS	NS	NS
N.Y.:	New York	8.80	11.83	11.97	15.24	14.21	34.36	8.21	9.35	7.24	6.66	3.73	4.09
Va.:	Sterling	6.85	7.62	9.95	18.03	12.67	10.98	7.54	4.27	4.17	2.49	1.86	2.97
Ocean station:	Echo	8.30	7.11	9.95	31.81	9.09	NS	6.94	3.77	3.13	3.10	2.60	3.51
Fla.:	Miami	9.37	13.20	15.79	26.67	19.10	23.15	6.30	3.56	2.07	4.14	5.34	NS
Bahamas:	Bimini	11.17	18.17	19.43	35.59	18.28	NS	7.05	4.10	2.53	5.01	5.92	5.18
Hawaii:	Mauna Loa	17.10	15.12	10.17	12.56	12.13	10.48	NS	3.05	3.22	2.22	NS	4.84
P.R.:	San Juan	5.05	5.55	12.23	17.04	8.82	8.10	6.74	5.57	3.49	1.85	3.03	3.81
Panama:	Balboa	4.07	6.77	8.82	4.96	4.26	.54	1.95	1.60	.99	(b)	[a].59	1.39
Ecuador:	Guayaquil	[a]2.12	[a]1.69	2.27	1.22	1.94	15.15	10.86	4.88	5.83	[a]3.59	[a]5.52	3.37
Peru:	Lima	11.79	6.94	3.52	2.00	2.28	11.65	25.02	14.77	11.40	13.92	9.82	5.02
Bolivia:	Chacaltaya	3.07	[a].91	.68	2.09	[a]1.41	27.48	NS	35.62	11.01	8.03	[a]6.33	1.97
Chile:	Antofagasta	9.81	7.51	3.26	3.01	2.88	12.73	31.44	18.76	9.72	9.88	9.85	5.71
	Portillo	17.05	7.60	4.84	5.99	7.57	NS	NS	NS	NS	NS	NS	NS
	Santiago	13.97	[a]16.79	7.87	5.22	[a]3.70	8.91	7.70	13.37	14.89	10.24	10.88	7.90
	Puerto Montt	7.55	7.41	4.60	3.82	2.10	NS	4.73	3.79	4.15	4.11	NS	3.93
	Punta Arenas	3.93	3.05	3.74	1.78	1.68	NS	1.05	1.70	[a]2.90	[a]1.81	[a]2.03	3.12

Errors are less than 20 percent except:

[a] error between 20–100 percent.

[b] error greater than 100 percent.

NS, no sample.

Table 11. Quality control results on blank samples—1967 (average values in dpm per sample)

Month	Iron-55	Strontium-89	Strontium-90	Zirconium-95	Cadmium-109	Cerium-141	Cerium-144	Plutonium-238	Plutonium-239
January	0	0	0	0	0	0	4.7	0	0
February	0	0	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0	0	0
May	904	<280	< 3	534	NS	0	1.7	.01	0
June	NS	<300	70	< 80	NS	<300	7	.01	.01
July	44	4.2	.9	3.5	2.7	12.6	.1	0	0
August	81	NS	NS	6.7	0	84	5.4	0	.08
September	49	1.8	.5	108	0	NA	1.5	.01	−.02
October	95	39	1.5	6.1	0	NA	.3	.08	.03
November	37	34	2.1	.5	0	NA	2.4	.30	.20
December	7.1	13	1.9	8.1	NA	6.9	.4	.17	.02

NA, no analysis.
NS, no sample.

Table 12. Quality control results on standard samples—1967 (average values in percent deviation)

Month	Iron-55	Strontium-89	Strontium-90	Zirconium-95	Cadmium-109	Cerium-141	Cerium-144	Plutonium-238	Plutonium-239
January	−21	− 7	0	−11	−39	− 7	+ 6	− 8	− 2
Feburary	− 2	+20	+70	− 7	−32	− 4	− 7	−13	−16
March	+ 5	+ 9	− 5	−12	− 8	+28	+ 4	− 2	− 1
April	+19	+14	− 8	−15	−17	+113	0	− 5	− 6
May	+ 1	+14	NA	−48	−99	− 45	− 5	−15	−12
June	+32	−12	+19	+ 8	−16	−100	−29	− 5	− 7
July	+11	+ 3	− 2	−12	−31	− 52	+ 8	−16	−14
August	− 3	+ 5	−18	−50	−33	− 27	+ 2	− 8	− 8
September	−15	− 4	−19	−40	−27	NA	+ 3	− 6	− 4
October	−13	+29	−14	− 4	−25	NA	+ 2	− 6	−14
November	+18	− 5	− 3	+20	−26	NA	− 3	+87	−11
December	+ 9	−14	−14	−16	NA	NA	+ 2	− 1	− 5

NA, no analysis.

Table 13. Quality control results on duplicate samples—1967 (values are ± percent standard deviation)

Month	Iron-55	Strontium-89	Strontium-90	Zirconium-95	Cadmium-109	Cerium-141	Cerium-144	Plutonium-238	Plutonium-239
January	NA	NA	NA	NA	NA	25	1	20	9
February	NA	NA	NA	NA	NA	4	0	17	13
March	16	2	7	NA	NA	NA	5	4	12
April	1	0	1	NA	15	NA	30	0	7
May	5	17	11	19	NA	NA	1	46	29
June	23	NA	NA	36	NA	NA	57	NA	NA
July	65	NA	8	NA	NA	NA	1	5	1
August	22	12	7	NA	NA	63	32	6	10
September	5	NA	2	46	NA	NA	NA	7	5
October	14	15	12	NA	NA	NA	2	25	21
November	25	5	14	2	NA	NA	0	12	11
December	NA	NA	NA	NA	NA	NA	NA	27	19

NA, no analysis.

with regular samples. Basically there are three kinds of quality control samples: blanks, standards and duplicates.

A blank is prepared by sprinkling a small amount of pre-1945 soil (10 mg) onto an unexposed microsorban filter. Then carbon soot from burning naphthalene is filtered onto the microsorban paper for a few moments under laboratory conditions. This procedure produces blanks which are very similar in appearance, and in some respects, composition to the routine filters collected by this program. When the blanks are coded, as are all the filters submitted to radiochemistry, they are not readily distinguishable from routine samples. Table 11 lists the results of analyses of blanks in 1967. The table summarizes the average dpm

L

reported from blanks sent out each month. It is evident from a review of these data that the contamination problem has been quite variable, and consequently low level concentrations in the real samples must be considered with care.

A standard is prepared at HASL by evaporating a known amount of radioactivity onto a blank filter. A few drops of wetting agent are applied to the blank prior to the addition of the standard to permit permeation of the solution between the polyethylene fibers of the microsorban filter. Table 12 presents the results of these analyses for each nuclide in 1967. The values are average percent deviations of the reported analyses from the known. Again the results are seen to be extremely variable and generally non-systematic.

Duplicates consist of collections made monthly at the New York site. Prior to December 1967 samples were composited and split before analyses thereby providing a measure of the reproducibility of the radiochemical procedures. The results of these tests are shown as the percent standard deviation from the mean, in table 13.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–December 1966	October 1970

REFERENCES

(*1*) VOLCHOK, H. L. The HASL Surface Sir Sampling Program summary report for 1963, HASL-156 (January 15, 1965).

(*2*) U.S. ATOMIC ENERGY COMMISSION HEALTH AND SAFETY LABORATORY. Surface Air Sampling Program, 1964, HASL-165. AEC Health and Safety Laboratory, 376 Hudson Street, New York, N.Y. 10014 (January 1, 1966).

(*3*) KREY, P. W. Surface Air Sampling Program, HASL-171. AEC Health and Safety Laboratory, 376 Hudson Street, New York, N.Y. 10014 (April 1, 1966).

(*4*) KREY, P. W. Surface Air Sampling Program, HASL-172. AEC Health and Safety Laboratory, 376 Hudson Street, New York, N.Y. 10014 (July 1, 1966).

(*5*) KREY, P. W. Surface Air Sampling Program, HASL-173. AEC Health and Safety Laboratory, 376 Hudson Street, New York, N.Y. 10014 (October 1, 1966).

(*6*) KREY, P. W. Surface Air Sampling Program, HASL-174. AEC Health and Safety Laboratory, 376 Hudson Street, New York, N.Y. 10014 (January 1, 1967).

(7) KREY, P. W. Surface Air Sampling Program HASL-182. AEC Health and Safety Laboratory, 376 Hudson Street, New York, N.Y. 10014 (July 1, 1967).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Strontium-90 in Human Bone, January-March 1970[1]

Bureau of Radiological Health
U.S. Public Health Service

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older-age groups have shown their bone strontium-90 content to be low and age independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the Bureau of Radiological Health at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium-90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated (*3*) from the yttrium-90 activity. For the purpose of maintaining analytical

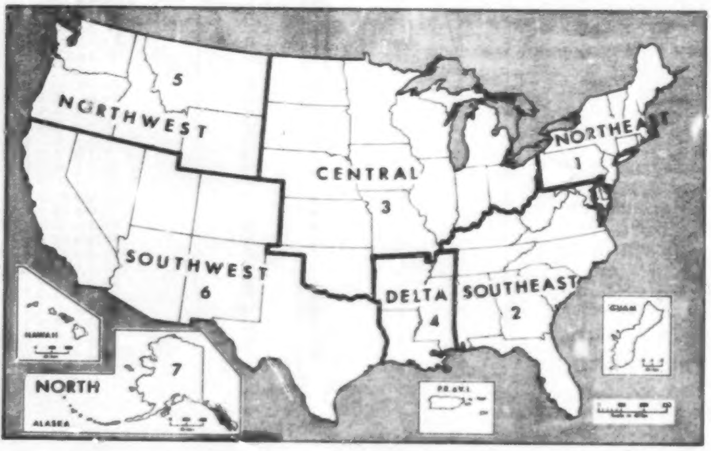


Figure 1. Geographical regions for human bone sampling

---

[1] Period during which death or surgical procedure occurred.

Table 1. Strontium-90 in human bone, January–March 1970

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Northeast:						
Pennsylvania	V	1	F	176.0±17.0	37.3	4.71
	V	2	M	78.9± 9.1	32.3	2.44
Massachusetts	V	2	M	94.2± 8.4	28.5	3.30
Pennsylvania	V	2	F	47.2± 6.9	32.8	1.43
New Hampshire	V	3	M	136.0±13.0	41.1	3.30
New York	V	3	M	55.3± 9.8	29.1	1.90
Pennsylvania	V	5	M	55.1± 6.6	21.8	2.52
Massachusetts	V	5	M	96.9± 9.9	31.1	3.11
Rhode Island	S	5	M	33.3± 6.[illegible]	20.6	1.61
Massachusetts	V	5	M	58.2± 8.1	20.9	2.78
New York	V	6	M	41.3± 7.2	23.4	1.76
	V	6	F	50.6± 6.3	28.7	1.76
Massachusetts	V	6	M	72.9±10.0	29.6	2.46
New Jersey	V	6	M	57.3± 5.9	26.2	2.18
Pennsylvania	V	9	M	57.9± 6.5	38.5	1.50
New York	V	10	F	52.0± 6.9	27.0	1.92
	V	11	M	64.1± 7.1	32.6	1.96
	V	12	F	103.0±12.0	72.5	1.42
	V	12	F	153.0±13.0	60.6	2.52
	V	13	M	71.8± 8.5	35.8	2.00
Pennsylvania	V	13	M	98.3±13.0	56.6	1.73
	V	13	F	106.0± 8.6	53.6	1.97
	V	14	M	72.8± 9.3	47.0	1.54
New York	V	15	F	118.0±11.0	57.4	2.05
Pennsylvania	V	15	F	147.0±18.0	61.7	2.38
	V	16	M	180.0±13.0	64.0	2.81
	V	16	M	77.1± 8.7	44.7	1.72
	V	16	M	102.0±12.0	52.7	1.93
New Jersey	V	16	M	105.0± 8.6	39.4	2.66
Pennsylvania	V	16	M	135.0±11.0	46.8	2.88
	V	18	M	113.0±10.0	54.1	2.08
Massachusetts	V	18	M	130.0± 8.3	39.9	3.25
New York	V	19	F	112.0± 9.3	44.3	2.52
Massachusetts	V	19	F	90.1±11.0	59.1	1.52
Pennsylvania	V	19	M	114.0±12.0	47.8	2.38
	V	19	M	126.0±10.0	57.2	2.20
New York	V	20	F	112.0±13.0	52.9	2.11
Massachusetts	V	20	M	125.0±12.0	49.1	2.54
New York	V	21	M	86.4± 8.4	53.3	1.62
Pennsylvania	V	21	M	106.0±12.0	54.3	1.95
	V	22	M	120.0±13.0	59.4	2.02
	V	23	M	45.7± 6.4	49.9	.91
Massachusetts	V	23	M	147.0±11.0	32.7	4.49
Pennsylvania	V	23	M	72.7± 9.4	54.2	1.34
Pennsylvania	V	24	F	51.3± 6.9	31.4	1.63
Southeast:						
South Carolina	V	0	F	92.7±10.0	26.3	3.52
	V	1	F	92.9± 9.9	25.8	3.60
Maryland	V	4	M	89.5±12.0	36.8	2.43
North Carolina	V	7	M	76.1± 8.4	27.6	2.75
Maryland	V	9	F	64.1± 9.1	33.2	1.93
South Carolina	V	10	M	91.3±11.0	42.2	2.16
Tennessee	V	15	M	78.8±10.0	49.7	1.58
South Carolina	V	16	M	94.8± 8.3	52.4	1.80
Alabama	V	18	M	113.0±12.0	46.2	2.44
Maryland	V	19	M	113.0±11.0	62.3	1.81
	V	20	M	78.8±10.0	58.5	1.34
South Carolina	V	21	M	77.3± 8.8	37.8	2.04
Maryland	V	21	F	81.0±10.0	55.8	1.45
South Carolina	V	23	F	70.5± 9.1	45.7	1.54
Maryland	V	24	M	85.3±11.0	48.5	1.75
	V	24	F	91.3±11.0	47.7	1.91
South Carolina	V	25	M	50.8± 8.0	43.3	1.17
Maryland	V	25	M	98.1±12.0	43.1	2.27
Central.						
Wisconsin	V	0	F	61.7± 7.5	33.5	1.84
	V	1	M	54.4± 8.1	28.7	1.90
Ohio	V	1	M	63.1± 8.6	30.3	2.08
Wisconsin	V	1	M	45.9± 8.0	28.3	1.62
	V	1	F	43.5± 9.1	26.1	1.66
	V	2	M	76.7± 9.0	36.8	2.08
	V	3	M	42.6± 6.1	27.2	1.56
Nebraska	V	3	F	72.1±10.0	30.7	2.34
Ohio	V	3	M	106.0±12.0	35.3	3.00
	V	3	F	127.0±10.0	35.0	3.62
Minnesota	V	6	M	41.1± 6.4	34.3	1.19
Michigan	V	6	M	75.4±11.0	34.0	2.21
	V	7	F	108.0±10.0	47.5	2.27
Minnesota	V	7	M	103.0±10.0	31.9	3.22
Ohio	V	8	M	95.2± 9.9	39.5	2.41
	V	8	F	39.3± 5.0	31.8	1.23
	V	8	M	67.5± 8.1	30.4	2.22
	V	9	M	59.5± 9.9	42.1	1.41
	V	11	F	86.2± 8.5	43.8	1.96
Minnesota	V	12	F	92.1± 7.2	39.6	2.32

See footnotes at end of table.

69

Table 1. Strontium-90 in human bone, January–March 1970—Continued

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Central: (Continued)						
Ohio	V	12	M	70.8± 7.4	37.4	1.89
Michigan	V	13	F	79.8± 9.3	49.7	1.60
Ohio	V	13	M	62.8± 6.1	37.8	1.66
	V	13	F	102.0± 9.8	43.1	2.36
	V	15	M	63.1± 8.0	46.7	1.35
	V	15	M	126.0±11.0	57.1	2.20
	V	16	M	102.0±12.0	51.1	1.99
	V	17	M	96.3±11.0	60.8	1.58
Wisconsin	V	17	M	101.0±10.0	57.4	1.75
Ohio	V	17	F	93.0±10.0	48.8	1.90
	V	17	F	81.9±10.0	51.5	1.59
	V	17	M	83.5±11.0	61.2	1.36
	V	19	F	78.7±10.0	53.9	1.46
	V	19	M	73.1±11.0	67.4	1.08
	V	20	F	73.4± 9.1	48.9	1.50
	V	20	M	80.0± 9.7	52.9	1.51
	V	21	F	90.1± 8.0	44.4	2.02
	V	21	F	101.0± 9.1	63.8	1.58
	V	21	M	137.0±14.0	60.2	2.27
	V	22	M	83.7± 8.2	53.3	1.55
	V	23	M	101.0±11.0	62.2	1.62
Delta:						
Louisiana	V	3	M	75.5± 8.5	33.2	2.27
	V	17	F	135.0±11.0	48.4	2.78
	V	20	M	119.0±14.0	76.1	1.56
	V, R	24	F	119.0±14.0	69.5	1.71
Northwest:						
Oregon	V	2	M	50.3± 7.6	30.8	1.63
	V	2	M	34.7± 6.6	29.8	1.16
	V	6	M	51.5± 7.0	32.7	1.57
	V	8	M	54.7± 7.0	30.0	1.82
	V	12	M	50.3± 6.6	35.8	1.40
Washington	V	16	M	55.5± 8.4	40.2	1.38
Oregon	V	21	M	79.5±10.0	56.5	1.40
	V	21	M	47.2± 6.4	43.2	1.09
Southwest:						
Texas	V	21	F	91.0±10.0	51.1	1.78
Utah	V	23	M	46.8± 5.3	33.3	1.40
North:						
Alaska	V	0	M	101.0±11.0	32.7	3.08
	R	15	M	419.0±36.0	115.0	3.64

[a] V—vertebra; S—sternum; R—rib.
[b] Age given as of last birthday prior to death.
[c] Two sigma counting error.

reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples.

The analytical results for strontium-90 in individual bones from persons dying during the first quarter (January–March) of 1970 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium-90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–6*).

REFERENCES

(*1*) RIVERA, J. Strontium-90 in human vertebrae, 1962–1963. Radiol Health Data 5:511–513 (October 1964).

(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Strontium-90 content of human bones, 1961–1963. Radiol Health Data 5:231–239 (May 1964).

(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples, chemical and radiochemical procedures, NERHL 64-1. Northeastern Radiological Health Laboratory, Winchester, Mass. (April 1964).

(*4*) GAFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium-90 in human bone, 1962–1963. Radiol Health Data 5:620–626 (December 1964).

(*5*) HALLISEY, R. M., and M. A. WALL. Strontium-90 in human bone, 1964–1965. Radiol Health Data Rep 8:415–419 (August 1967).

(*6*) BARATTA, E. J., E. S. FERRI, and M. A. WALL. Strontium-90 in human bones in the United States, 1962–1966. Radiol Health Data Rep. 11:183–186 (April 1970).

70

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Argonne National Laboratory and the National Reactor Testing Station.

---

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Argonne National Laboratory July-December 1969

University of Chicago
Lemont, Ill.

The radioactivity of the environment is determined on a continuing basis by measuring the radioactivity in naturally-occurring materials collected both on and off the Argonne National Laboratory site. Since radioactivity is usually spread by air and water, the environmental monitoring program at Argonne has concentrated on these materials. The sampling locations discussed in this report are shown in figures 1 and 2.

Air monitoring

The radioactivity of particulate matter in air was determined by drawing air through filter paper at a known rate and measuring the radioactivity of the particles collected by the paper. The samples were collected continuously at seven locations on the Argonne site and at five locations off the site. At one location on the site the filter paper was changed daily; at all other locations the filter papers were changed at weekly intervals. The daily samples record short-term changes in radioactivity, while the weekly samples are used to compare onsite and offsite activities. Higher activities on the site are indicative of radioactivity released by Argonne if the differences are greater than the 10 to 20 percent error in sampling and counting. The alpha and beta radioactivity in air-filter samples are summarized in table 1; the average concentration of gamma-ray emitters as determined by gamma ray spectrometry are summarized in table 2. The alpha radioactivity concentrations were due principally to naturally-occurring radionuclides and were in the range found in previous years. As in the past, much of the beta and gamma radioactivity was due to fission and neutron activation products from nuclear detonations, although about one-third of the gamma radioactivity and a smaller fraction of the beta radioactivity was due to beryllium-7, produced continuously in the upper atmosphere by cosmic-ray interactions. The total beta radioactivity and all the gamma-ray emitters for which positive results were obtained, including the naturally-occurring beryllium-7, increased steadily from January to August 1969, then decreased during the remainder of the year. This behavior is attributed to the usual "spring maximum" in stratospheric fallout, although the peak was broader than in the past several years. Most of the fission products in the samples were injected into the atmosphere several months before they were observed, probably about December 1968, since the shortest-lived fission product detected in the spring was cerium-141 and the most abundant fission products were zirconium-95 and niobium-95. The presence of a very small amount of barium-140 (~1 fCi/m^3) in the air during the middle of January supports the suggestion that most of the fission products were produced in December 1968. The delay in its appearance implies high-altitude injection, or possibly an increased spring fallout rate from the troposphere by rain washout.

The average beta radioactivity for the year (0.23 pCi/m^3) was about 10 percent higher than

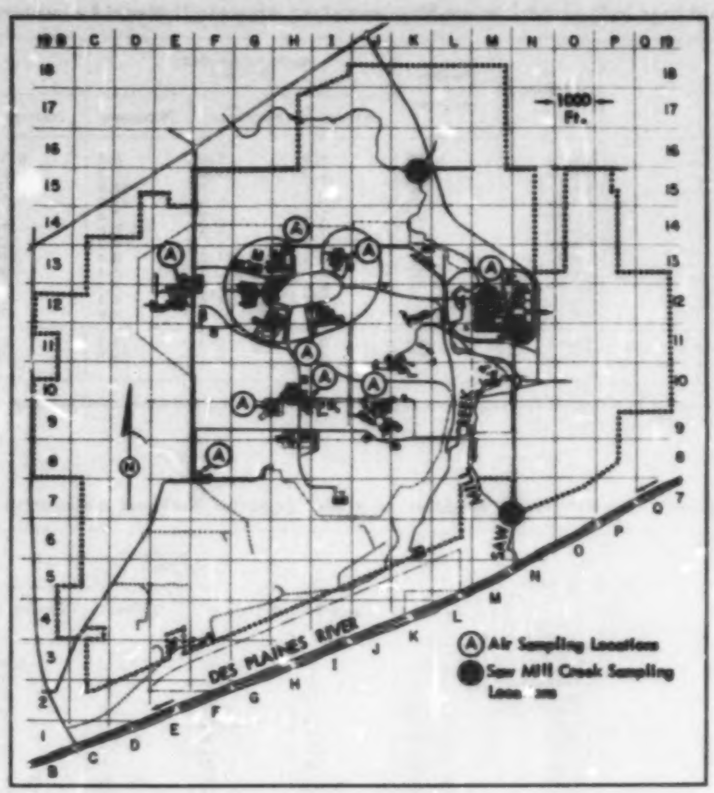

1000 Ft.
DES PLAINES RIVER
SAW MILL CREEK
Air Sampling Locations
Saw Mill Creek Sampling Locations

Figure 1. Onsite sampling locations at Argonne National Laboratory

during 1968. Most of the gamma-ray emitters were also present in slightly higher concentrations this year.

Precipitation collected on the site contained the same fission products found in air samples. Composite large volume rain samples were also analyzed monthly for iron-55. The average monthly concentrations ranged from 9 to 890 pCi/m^2 of surface. The average for the year (180 pCi/m^2) was a factor of three greater than the 1968 average. However, if the unusually large value of 890 pCi/m^2 in June 1969 is excluded, the average decreased to 110 pCi/m^2. Iron-55 is a neutron activation product and was produced mainly in nuclear tests conducted in September and October 1961. Therefore, the above concentrations have been corrected for decay to October 15, 1961, for comparison purposes. Since iron-55 decays by electron capture and does not emit any gamma-

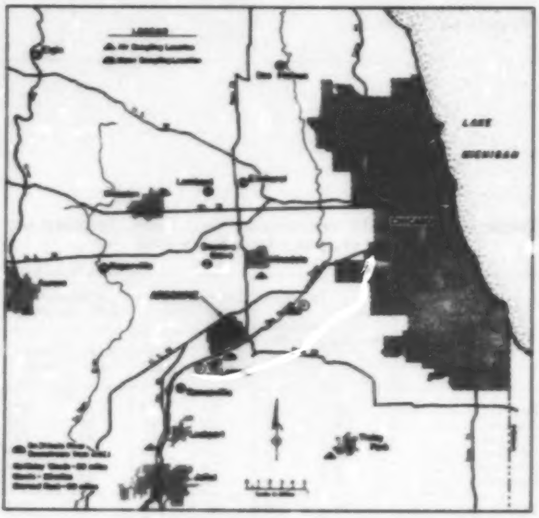

LAKE MICHIGAN
CHICAGO

Figure 2. Locations of Argonne National Laboratory (including some offsite sampling stations)

Table 1. Alpha and beta radioactivity in air-filter samples,[a] Argonne National Laboratory, July–December 1969

(1969)	Location	Number of samples	Alpha radioactivity (fCi/m³)			Beta radioactivity (pCi/m³)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	Onsite	22	3.0	1.6	5.5	0.38	0.20	0.61
	Offsite	20	4.9	1.6	12.9	.41	.15	.57
August	Onsite	25	4.1	.3	14.5	.51	.13	.80
	Offsite	21	4.8	2.6	15.0	.54	.19	.80
September	Onsite	23	3.5	1.0	7.8	.19	.09	.48
	Offsite	22	5.0	2.5	7.9	.24	.09	.42
October	Onsite	27	3.2	1.1	7.3	.13	.06	.21
	Offsite	22	3.8	1.5	9.4	.16	.10	.36
November	Onsite	25	3.0	1.5	8.1	.08	.04	.12
	Offsite	18	3.4	2.2	5.8	.09	.04	.13
December	Onsite	24	2.8	1.4	4.4	.07	.03	.11
	Offsite	22	3.8	1.6	9.9	.08	.05	.11
Annual summary	Onsite	300	3.3	0.3	14.5	.21	0.03	0.80
	Offsite	255	4.1	0.5	15.0	.24	0.04	0.80

[a] These results were obtained by measuring the samples four days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products.

Table 2. Gamma-ray radioactivity in air-filter samples, Argonne National Laboratory, July–December 1969

Radionuclide	Location	Concentration (pCi/m³)						
		July	August	September	October	November	December	Annual summary
Barium-lanthanum-140	Onsite	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Offsite	< .01	< .01	< .01	< .01	< .01	< .01	< .01
Beryllium-7	Onsite	.11	.13	.11	.07	.07	.06	.09
	Offsite	.10	.14	.11	.07	.05	.05	.08
Cerium-141	Onsite	.01	.01	< .01	< .01	< .01	< .01	.01
	Offsite	.01	.01	< .01	< .01	< .01	< .01	.01
Cerium-144	Onsite	.05	.07	.03	.02	.01	.01	.03
	Offsite	.06	.06	.03	.02	.01	.01	.02
Cesium-137	Onsite	< .01	< .01	< .01	< .01	< .01	< .01	< .01
	Offsite	< .01	< .01	< .01	< .01	< .01	< .01	< .01
Iodine-131	Onsite	< .01	< .01	< .01	< .01	< .01	< .01	< .01
	Offsite	< .01	< .01	< .01	< .01	< .01	< .01	< .01
Ruthenium-103	Onsite	.02	.03	< .01	< .01	< .01	< .01	.01
	Offsite	.02	.02	< .01	< .01	< .01	< .01	.01
Ruthenium-rhodium-106	Onsite	.09	.09	.06	.04	.02	.02	.05
	Offsite	.08	.09	.07	.05	.02	.02	.05
Zirconium-niobium-95	Onsite	.15	.17	.07	.03	.02	.02	.06
	Offsite	.17	.18	.07	.03	.02	.01	.06

Table 3. Argon-41 concentrations, near Juggernaut Reactor, July–December 1969

Month (1969)	Number of samples	Number of samples > 20 nCi/m³	Concentration[a] (nCi/m³)		Percent of AEC standard	
			Average	Maximum	Average	Maximum
July	30	8	24	152	60	380
August	28	2	12	40	30	100
September	16	5	25	77	63	193
October	16	2	10	26	25	65
November	8	1	15	49	38	123
December	24	4	22	106	45	265
Annual summary	302	56	22	152	45	380

[a] Minimum detectable concentration, 20 nCi/m³.

rays, this nuclide does not contribute to the beta and gamma activities presented in tables 1 and 2. The neutron activation products, tungsten-181 and 185, were also detected in some precipitation samples.

Air was also sampled continuously for radioiodine with activated charcoal in the 200 and 300 Areas because of the possibility of iodine releases in these areas. No radioactivity above the minimum detectable concentration of 0.1 pCi/m³ was detected at either location.

Air sampling for argon-41 (a beta-particle emitter with a 1.8 hour half-life that is produced in an operating reactor by the action of neutrons on the stable argon-40 in air) was conducted near the Juggernaut reactor (Building 335) from March through December. The results are tabulated in table 3. These concentrations are based on one-minute grab samples taken at a position downwind from the reactor at a point favorable for argon-41 detection after the reactor has been in operation for several hours. Therefore, the actual average concentrations in the 300 Area were much less than the values in the table. The argon-41 concentration in the exhaust from the Juggernaut is about 260 μCi/m^3, so the average dilution by outside air in the samples collected was about a factor of 10^4. In 1968, argon-41 concentrations were measured in the vicinity of the CP-5 reactor (Building 330), which operates at a power level about 20 times higher than Juggernaut. The CP-5 reactor is undergoing rehabilitation and is not being operated this year. A comparison of the argon-41 concentrations near the two reactors is of interest. In 1968, argon-41 was detected in about 46 percent of the samples collected near CP-5. The average concentration was 140 nCi/m^3. The fraction of positive results near the Juggernaut reactor in 1969 was appreciably less (28 percent), while the average concentration (22 nCi/m^3) was six times smaller. In the CP-5 reactor the air that is exposed to neutrons is diluted with a large volume of inactive air before it is discharged. This means that the argon-41 concentrations in the air leaving the two reactor buildings are not greatly different, although the volume of air (containing argon-41) is about 15 times greater from CP-5. As a result, the argon-41 concentration in outside air averaged only six times less than the Juggernaut, although the argon-41 production is about 20 times less than CP-5.

Air was sampled for tritiated (hydrogen-3) water vapor 50-yards west of the CP-5 reactor. The results are given in table 4. The results were positive in all but a few samples, although the concentrations were well below the AEC standards. This nuclide is produced continuously while the reactor is in operation by the action of neutrons on the heavy water used for moderating and cooling. The average concentration this year (400 pCi/m^3) was about three times higher than the 1968 average. Eighteen samples were also collected between May and December 1969 in the east area, 1,829 meters (2,000 yards) from the reactor. In these samples, the tritium concentration ranged from less than 10 to 45 pCi/m^3 and averaged 15 pCi/m^3. Samples collected near the reactor at the same time averaged 660 pCi/m^3. The east area samples generally varied in the same manner as the activity in the samples near CP-5. For example, the highest concentrations at both locations, (45 and 5,750 pCi/m^3) were found in samples collected on the same day, and east area samples, (greater than 10 pCi/m^3) were found only on those days when the CP-5 samples contained more than 90 pCi/m^3. The correlation is sufficiently good to conclude that most of the tritium in the east area samples came from the CP-5 reactor. Although the reactor has not been in operation since January 1969, the heavy water containing the long-lived tritium was handled while the reactor was dismantled and small quantities evidently did escape from the building.

Table 4. Tritium concentrations near CP-5 reactor July-December 1969

Month (1969)	Number of samples	Concentration (pCi/m^3)			Percent of AEC standard	
		Average	Minimum	Maximum	Average	Maximum
July	3	105	99	133	0.05	0.07
August	11	190	100	507	.10	.25
September	11	210	<10	1,804	.11	.90
October	4	95	20	175	.05	.09
November	7	754	41	1,525	.38	.76
December	10	2,330	392	5,750	1.17	2.88
Annual summary	122	400	<10	5,750	0.20	2.88

Water monitoring

Argonne wastewater is discharged into Sawmill Creek, a small stream that runs through the Argonne grounds and enters the Des Plaines River about 500 yards downstream from the wastewater discharge. Sawmill Creek was sampled upstream from the Argonne site and downstream from the wastewater outfall to determine if radioactivity was added to the stream in Argonne wastewater. The sampling locations are shown in figure 1.

Below the wastewater outfall the creek was usually sampled three to five times weekly. Since it was impractical to analyze all the samples for all the radionuclides and elements desired, equal portions of the individual samples collected each week were combined and analyzed. The results

Table 5. Non-volatile alpha and beta radioactivity in Sawmill Creek water, Argonne National Laboratory, July–December 1969

Month (1969)	Location[a]	Number of samples	Alpha radioactivity (pCi/liter)			Beta radioactivity (pCi/liter)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	Upstream	2	3.3	2.1	4.5	20	15	25
	Downstream	15	1.4	.2	3.0	16	13	21
August	Upstream	2	2.4	1.7	3.2	15	11	19
	Downstream	24	2.4	1.6	3.4	21	14	40
September	Upstream	2	6.2	6.1	6.2	32	29	34
	Downstream	20	2.1	1.3	3.6	19	16	21
October	Upstream	2	1.9	1.4	2.3	22	14	30
	Downstream	25	1.5	.2	3.5	18	13	25
November	Upstream	2	2.5	2.1	2.9	14	11	17
	Downstream	18	1.9	1.5	2.2	13	12	14
December	Upstream	2	2.3	2.2	2.3	6.3	6.1	6.4
	Downstream	23	2.7	1.2	4.5	14	13	15
July–December summary	Upstream	12	3.1	1.4	6.2	18	6.1	34
	Downstream	121	2.0	.2	4.5	17	12	40
Annual summary	Upstream	24	3.0	1.4	6.2	16	6.1	34
	Downstream	214	2.2	.2	4.5	15	8.7	40

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

obtained in this way represent the average concentrations in the weekly samples. Above the site, samples were collected twice monthly and at least one sample each month was analyzed for each radionuclide of interest. The total alpha and beta radioactivities found in Sawmill Creek during July–December 1969 are given in table 5. Upstream from the Argonne site, the alpha activity was due primarily to radioactive nuclides that occur naturally in the stream, and was in the normal range. Any additional activity downstream was due to alpha-emitting nuclides in the wastewater. The concentration of alpha activity in the creek resulting from the presence of Argonne wastewater can be estimated as follows.

Below the outfall, the Argonne wastewater was diluted from one to ten times by creek water during July–December 1969. This increased dilution above previous years is due to the discharge into the creek of water from a new public sewage disposal plant north of the laboratory. Consequently, the natural alpha activity in the creek below the outfall varied from 50 to 90 percent of the upstream concentration and the alpha activity added by Argonne wastewater varied from 0.7 to less than 0.1 pCi/liter. Although Argonne wastewater contained a small quantity of alpha activity, its addition to the creek did not increase the total alpha activity in the stream. On some days, when below-outfall water contained less alpha activity than upstream water, the wastewater evidently contained less alpha activity than natural creek water. The unusually high alpha activity for this location in the September upstream was accompanied by an unusually large amount of dissolved solids. These two samples increased the above site annual average from 2.6 to 3.0 pCi/liter.

The alpha-particle emitters most likely to be present in Argonne wastewater are isotopes of uranium, plutonium, and thorium. The alpha radioactivity in the creek water due to these elements are summarized in table 6. The concen-

Table 6. Alpha-emitting elements in Sawmill Creek water, Argonne National Laboratory, July–December 1969

Element	Location[a]	Number of samples	Concentration (pCi/liter)			Percent of AEC standard	
			Average	Minimum	Maximum	Average	Maximum
Uranium	Upstream	6	2.0	0.9	3.4	0.005	0.009
	Downstream	57	1.6	.7	2.9	.004	.007
Plutonium	Upstream	6	—	—	< .05	—	< .001
	Downstream	58	—	—	< .05	—	< .001
Thorium	Upstream	6	—	—	< .05	—	< .003
	Downstream	58	—	—	< .05	—	< .003

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

trations are low compared to the AEC standards. The uranium content attributable to Argonne below the outfall ranged from 0.6 to less than 0.1 pCi/liter, depending on the dilution (about the same as during 1968). The amount of uranium in the wastewater, however, was too low to increase the concentration in the creek water, and, as was the case for total alpha radioactivity, on some days the wastewater contained less uranium than the creek water. Comparison of the data in table 6 with the total alpha radioactivity indicates that most of the alpha activity in the creek was due to uranium. The alpha to uranium ratio (about 1.5) at both locations is normal for surface water in the area and the remaining alpha activity is usually due to uranium decay products.

In addition to the natural beta radioactivity in the creek, beta activity from nuclear detonations was detected at both sampling locations and beta radioactivity from Argonne wastewater was found in some samples below the outfall. The natural beta radioactivity is approximately 5 pCi/liter above the site and 2 to 5 pCi/liter below the site depending on the amount of dilution by wastewater. It is estimated that fallout activity added about 10 pCi/liter to the nonvolatile beta radioactivity at both locations (fallout is added to the water below the outfall directly from the air as well as by above-site water) and the Argonne contribution below the outfall averaged 2 pCi/liter. The Argonne contribution decreased to one-third of the 1968 levels, while the fallout contribution remained about the same.

The results of analyses of Sawmill Creek water for specific beta-emitting nuclides are summarized in table 7. The principal beta-particle emitter added to the creek by Argonne wastewater was tritium. This radionuclide, present as water (HTO), is not included in the total beta activity in table 5. Separate samples were analyzed specifically for tritium. Although small amounts are produced by cosmic-ray interactions with the atmosphere, the bulk of the tritium in above-site water originated in nuclear detonations. Although some of the other nuclides listed were also added to the creek by fallout, the total concentration regardless of source, must be used in assessing the health hazard of a radioactive nuclide not naturally present in the environment. The percent of the AEC standard given in the table was calculated on this basis. As indicated in the table, the beta activities in the creek were very low compared to the AEC standards.

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in the latter two streams is important in assessing the contribution of Argonne wastewater to the environmental radioactivity. The Des Plaines River was sampled monthly above the mouth of Sawmill Creek and weekly below the mouth to determine if the radioactivity in the creek has any effect on the radio-

Table 7. Beta-emitting radionuclides in Sawmill Creek water, Argonne National Laboratory, July-December 1969

Radionuclide	Location[a]	Number of samples	Beta radioactivity (pCi/liter)			Percent of AEC standard	
			Average	Minimum	Maximum	Average	Maximum
Barium-140	Upstream	6	—	—	< 2	—	<0.007
	Downstream	57	—	—	< 2	—	< .007
Cerium-144	Upstream	12	—	—	<10	—	< .1
	Downstream	121	—	—	<10	—	< .1
Cesium-137	Upstream	6	—	—	< .5	—	< .003
	Downstream	121	1.0	< 0.5	3.1	0.005	.016
Cobalt-58	Upstream	12	—	—	<10	—	< .01
	Downstream	121	—	—	<10	—	< .01
Cobalt-60	Upstream	12	—	—	<10	—	< .02
	Downstream	121	—	—	<10	—	< .02
Tritium	Upstream	6	500	<400	1,000	.02	.03
	Downstream	121	2,400	600	18,600	.08	.62
Iodine-131	Upstream	0	—	—	—	—	—
	Downstream	121	—	—	< 3	—	<1
Strontium-89	Upstream	6	—	—	< 2	—	< .07
	Downstream	57	—	—	< 2	—	< .07
Strontium-90	Upstream	6	1.7	< 0.5	3.4	.6	1.1
	Downstream	57	1.5	.8	1.9	.3	.6
Technetium-99	Upstream	6	—	—	.5	—	< .0002
	Downstream	121	< .5	< .5	1.0	< .0002	.0003
Thorium-protactinium-234	Upstream	6	1.6	.7	2.7	.008	.014
	Downstream	57	1.3	.5	2.3	.007	.012

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

76

Table 8. Average radioactivity in Des Plaines and Illinois River water Argonne National Laboratory, 1969

Location	Concentration (pCi/liter)			
	Nonvolatile alpha radioactivity	Uranium	Nonvolatile beta radioactivity	Tritium
Des Plaines River[a] (above Sawmill Creek)	[b] 3.9(12)	1.9(3)	14(12)	<400(6)
Des Plaines River[c] (below Sawmill Creek)	3.4(53)	1.9(13)	15(53)	2,300(34)
Illinois River[d]	2.4(4)	2.1(2)	8(4)	<400(4)

[a] Sampled near Route 45, upstream from the mouth of Sawmill Creek.
[b] Number in parenthesis is number of samples.
[c] Sampled near Lemont, downstream from the mouth of Sawmill Creek.
[d] Sampled at McKinley Woods State Park, Morris, and Starved Rock State Park.

Table 9. Radioactivity in Des Plaines River water, Argonne National Laboratory July–December 1969

Radionuclide	Location[a]	Number of samples	Concentration (pCi/liter)		
			Average	Minimum	Maximum
Barium-lanthanum-140	Upstream	4	—	—	< 2
	Downstream	8	—	—	< 2
Cerium-144	Upstream	6	—	—	< 10
	Downstream	27	—	—	< 10
Cobalt-58-60	Upstream	6	—	—	< 10
	Downstream	27	—	—	< 10
Tritium	Upstream	3	<400	<400	620
	Downstream	12	5,700	<400	11,000
Plutonium (alpha)	Upstream	3	—	—	< .05
	Downstream	6	—	—	< .05
Strontium-89	Upstream	3	—	—	< 2
	Downstream	6	—	—	< 2
Strontium-90	Upstream	3	1.5	1.3	1.8
	Downstream	6	1.9	1.3	2.9
Thorium-protactinium-234	Upstream	2	1.3	1.1	1.4
	Downstream	7	1.6	1.0	2.2
Uranium	Upstream	2	1.8	1.5	2.0
	Downstream	7	2.0	1.2	2.8

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

activity in the river. The total radioactivity is summarized in table 8, and the results of analysis for specific elements and radionuclides are given in table 9. Tritium was the only nuclide whose concentration was higher below the mouth of Sawmill Creek, and the additional activity at this location evidently originated in Argonne wastewater. However, the average and maximum concentrations below the creek amounted to only 0.08 and 1.1 percent, respectively, of the AEC standards. The concentration of tritium in the river above the creek is similar to that found last year in the Des Plaines River and to that found in other streams in the area. This nuclide occurs naturally and is also present in debris from nuclear tests.

The concentrations of the other radionuclides and of the total alpha and beta radioactivities were in their normal ranges at both locations. The annual average beta radioactivity (15 pCi/liter) was about the same as 1968. The natural nonvolatile beta radioactivity in the river is 5 to 10 pCi/liter, and the excess (about 7 pCi/liter) was due to fallout. The total radioactivity in samples of Illinois River water were normal and similar to those found in other streams in the area. No evidence of radioactivity in Argonne was detected. The tritium concentrations in the Illinois River samples were less than 400 pCi/liter.

Radioactivity in milk

Raw milk was collected monthly from a local dairy farm and analyzed for several fission products. Strontium-89, iodine-131, and barium-140 were not present in concentrations greater than the minimum detectable amounts of 20 pCi/liter for iodine-131 and 5 pCi/liter for the other two radionuclides. The strontium-90 and cesium-137 concentrations are given in table 10. These two radionuclides are long-lived fission products from past nuclear tests and their presence in milk is not related to Argonne operations. The average strontium-90 content changed little compared to last year, while the cesium-137 concentrations were about 35 percent lower.

Table 10. Fission product concentration in milk July-December 1969

Date collected (1969)	Concentrations (pCi/liter)	
	Cesium-137	Strontium-90
July 3	20	9.5
August 6	23	6.6
September 2	26	3.1
October 8	30	6.5
November 5	30	8.0
December 3	27	5.8
Annual average	24	6.4

Conclusion

Argonne's contribution to the environmental radioactivity was primarily limited to tritium and argon-41 in the air and to tritium in water from Sawmill Creek and the Des Plaines River. The only activity detected off the site were the low levels of tritium in the two streams.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1968	February 1970
January–June 1969	July 1970

---

2. National Reactor Testing Station[3]
January-June 1969

Health Services Laboratory
U.S. Atomic Energy Commission
Idaho Falls, Idaho

Data from the environmental monitoring network on and around the National Reactor Testing Station (NRTS) in eastern Idaho revealed that NRTS operations during the first half of 1969 did not contribute significantly to environmental radiation or radioactivity concentration levels. These levels remained well below the Atomic Energy Commission (AEC) standards as set forth in AEC Manual Chapter 0524. These standards are based on FRC recommendations. The concentrations of radioactivity reported include contributions from all sources, such as fallout and natural radioactivity. Samples of air, water and milk are collected routinely at stations shown in figure 3. The results of the analyses performed on the air, water, and milk samples are shown in table 11 for January–June 1969.

Water monitoring

Water containing small quantities of radioactivity is returned to the ground through ponds and wells at the NRTS. The radioactivity in the water is measured before discharge to make sure that standards are not exceeded in the environment. Radioactivity is also monitored in the ground water from onsite and offsite sampling locations. Samples are analyzed for gross alpha and gross beta radioactivity and tritium. Offsite surface water samples are also collected from the Snake River at Idaho Falls and Bliss. With the exception of tritium at some onsite sampling locations, the radioactivity in both onsite and offsite water was usually not subtracted from the levels measured onsite. The average concentrations of all types of radioactivity in onsite and offsite water were less than 11 percent of their respective AEC guides.

Air monitoring

Radioactive materials in the atmosphere are collected by drawing air through filters. The samplers operate continuously, and the filters are changed weekly. The filters are analyzed for gross alpha, gross beta and iodine-131 radioactivity.

---

[3] Summarized from "Environmental Monitoring Report No. 24, January–June 1969," U.S. Atomic Energy Commission, Idaho Operations Office, Health Service Laboratory.

78

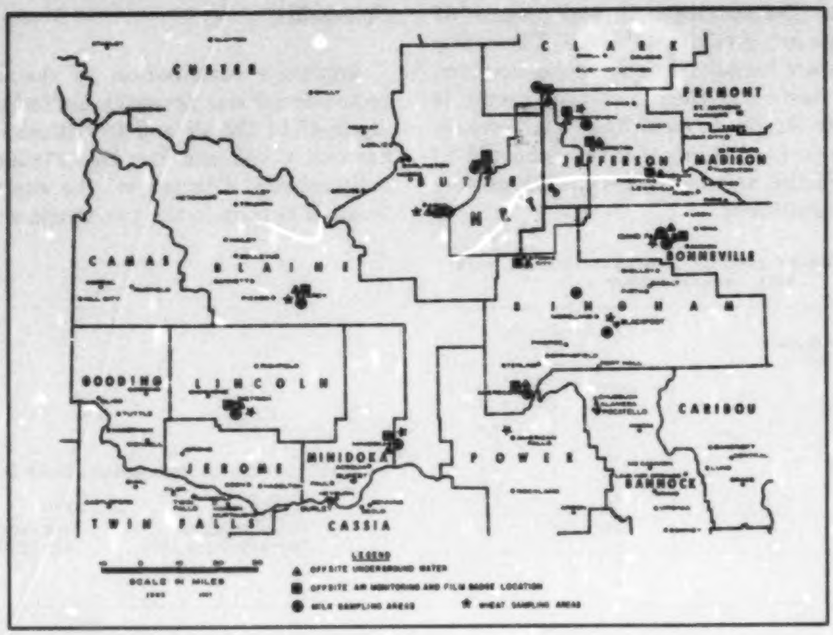

CUSTER
CLARK
FREMONT
JEFFERSON
MADISON
BUTTE
NRTS
CAMAS
BLAINE
BONNEVILLE
BINGHAM
GOODING
LINCOLN
CARIBOU
MINIDOKA
JEROME
POWER
BANNOCK
TWIN FALLS
CASSIA
SCALE IN MILES
LEGEND
OFFSITE UNDERGROUND WATER
OFFSITE AIR MONITORING AND FILM BADGE LOCATION
MILK SAMPLING AREAS
WHEAT SAMPLING AREAS

Figure 3. Environmental monitoring stations, National Reactor Testing Station

Table 11. Environmental monitoring data for the National Reactor Testing Station, January–June 1969

Type of sample and units	Number of samples	Type of radioactivity	Minimum level of detection	Maximum radioactivity of single sample	Average radioactivity per sample	AEC standard
Onsite production well water (pCi/liter)	244	Alpha Beta Tritium	3 5 [a] 2	6 66 [a] 131	< 3 < 6 [a] 8.9	400 3,000 [a] 100,000
Offsite underground water (pCi/liter)	12	Alpha Beta Tritium	3 5 [a] 2	4 5 [a] < 2	< 3 < 5 [a] < 2	30 100 [a] 3,000
Surface water (pCi/liter)	2	Alpha Beta Tritium	3 5 [a] 2	3 5 [a] < 2	< 3 < 5 [a] < 2	30 100 [a] 3,000
Onsite air (pCi/m^3)	208	Alpha Beta Iodine-131	.001 .003 .01	.023 1.9 .11	.003 .47 < .02	.6 300 9,000
Offsite air (pCi/m^3)	52	Alpha Beta Iodine-131	.001 .003 .01	.013 1.6 .14	.004 .46 < .02	.2 10 100
Offsite milk (pCi/liter)	91	Iodine-131 Strontium-90	20 1	<20 5	<20 2	100 200
Offsite thermoluminescent dosimeters (mRem/6 months)	6	Gamma	5	6	< 5	85
On and offsite public highways:						
Highway 20	38	Gamma	5	18	< 5	85
Highway 88	19	Gamma	5	7	< 5	85
Highway 22	13	Gamma	5	< 5	< 5	85
Highway 28	8	Gamma	5	< 5	< 5	85

[a] Concentration of tritium in nCi/liter.

79

Samplers are located at eight locations onsite as shown in figure 3. Background concentrations are measured in Idaho Falls. The average gross beta concentration at the NRTS was not significantly different from background. This was also true for the average iodine-131 concentrations. On the other hand, the average concentration of gross alpha radioactivity continued to be significantly higher in Idaho Falls than at the NRTS. The average gross alpha concentration (including background) was less than 20 percent of the maximum permissible concentrations, if one assumes all the radioactivity was due to the most hazardous isotope that could possibly be in the air.

Because the alpha radioactivity levels observed are not much larger than the concentrations present from natural sources, it is very difficult to determine what isotope or isotopes are present. However, analyses made to date indicate that the increased levels in Idaho Falls are due to polonium-210 which occurs naturally in rocks and soil as a daughter product of natural uranium. If heated, polonium is readily volatilized into the atmosphere. In fact, some polonium is normally present in the air from decay of radon-222, which, being a gas, regularly diffuses from the ground.

Partly to find an explanation for the higher alpha radioactivity levels and partly to obtain a more representative background for NRTS measurements, another sampler was set up at Fanning Field in northwestern Idaho Falls. Also, samplers were set up northwest of Blackfoot and in Arco and Butte City.

The average gross alpha radioactivity measured in Idaho Falls was the same as that measured in Blackfoot. On the other hand, the levels in Butte City and Arco were lower, being roughly equal to those measured at the NRTS. This indicates that the higher gross alpha radioactivity levels are probably restricted to an area east of the NRTS. This radioactivity is not related to NRTS operations. All air monitoring results are listed in table 11.

Offsite milk monitoring

Offsite milk samples are collected from 12 locations routinely and analyzed for strontium-90 and iodine-131. A composite grade A sample is collected weekly from an Idaho Falls dairy. This composite sample contains milk from areas north, south and east of NRTS. Milk samples are collected monthly from all sampling locations. The sampling locations are shown in figure 3, and the results are given in table 11. No iodine-131 was detected at any time during the year. The strontium-90 concentrations are attributed to worldwide fallout and have shown a decline in recent years.

Gamma radiation levels

The external gamma radiation is measured with thermoluminescent dosimeters. The exposure results reported in table 11 represent net values after subtracting natural background exposures. Aberdeen, Carey, Deitrich, Idaho Falls, and Minidoka were used to determine background radiation exposure. The offsite locations are Arco, Atomic City, Howe, Monteview, Reno Ranch, and Roberts. No significant radiation exposures were observed.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	August 1969
July–December 1968	June 1970

Reported Nuclear Detonations, December 1970

(Includes seismic signals presumably from foreign detonations)

Seismic signals, presumably from a Soviet underground nuclear explosion, were recorded by the United States on December 12, 1970. The signals originated at approximately 2:00 a.m., EST, in the Kazakh Desert, south of the Urals, and were equivalent to those of an underground nuclear test in the intermediate yield range (200 kilotons to 1 megaton TNT equivalent).

The U.S. Atomic Energy Commission conducted two underground nuclear tests at its Nevada Test Site on December 16, 1970. The first test was in the low yield range of less than 20 kilotons TNT equivalent. The second test was in the low-intermediate yield range (20 to 200 kilotons TNT equivalent).

There was some release of radioactivity from the first test of December 16, 1970. Radioactivity at very low levels, (less than 1 milliroentgen per hour) was recorded on the ground along State Highway 25, north of the test site. Monitors and aircraft of the Environmental Protection Agency (formerly the U.S. Public Health Service) monitored the situation continuously. The radioactive air mass moved slowly north and northwest, widening gradually as it moved. Aircraft kept the air mass defined and instruments recorded levels of a few milliroentgens per hour several thousand feet above the ground. None of the readings indicated that there would be a health hazard to persons living downwind.

On December 17, 1970, the United States recorded seismic signals which originated from the Soviet nuclear test area in the Semipalatinsk region. The signals were equivalent to those of a nuclear test in the low-intermediate yield range (20–200 kilotons TNT equivalent).

Also on December 17, 1970, the Atomic Energy Commission announced that it had conducted an underground nuclear test in the intermediate yield range (200 kilotons to 1 megaton TNT equivalent) at its Nevada Test Site.

Seismic signals were recorded by the United States on December 23, 1970, presumably from a Soviet underground nuclear explosion. The signals originated from the Kazakh Desert south of Urals, and were equivalent to those of an underground nuclear test in the intermediate yield range of 200 kilotons to 1 megaton.

Information in this section is based on data received during the month, and is subject to change as additional information may become available. Persons requiring information for purposes of compiling announced nuclear detonation statistics are advised to contact the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1971—[illegible]

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

ESTIMATES OF POTENTIAL DOSES TO VARIOUS ORGANS FROM X-RADIATION EMISSIONS FROM COLOR TELEVISION PICTURE TUBES. *Robert H. Neill, Harry D. Youmans,* and *John L. Wyatt. Radiological Health Data and Reports, Vol. 12, January 1971,* pp. 1–6.

Using the exposure rates determined in the metropolitan Washington color television survey, doses to various organs of children and adults were calculated. For a television receiver with a picture tube emitting 0.5 mR/h (the maximum exposure rate allowed under the Department of Health, Education and Welfare performance standards) and with other specified assumptions, the calculated dose to a child ranged from 5 mrem/a (female gonads) to 42 mrem/a (skin). For an adult, the doses were 2 mrem/a to 18 mrem/a, respectively. Using the same assumptions but for a picture tube emitting 0.043 mR/h (the average exposure rate observed in the metropolitan Washington survey), the respective doses were 0.4 mrem/a to 3.6 mrem/a for a child and 0.2 mrem/a to 1.6 mrem/a for an adult.

KEYWORDS: Doses, color television, organs, x radiation.

SURVEYS OF RADIUM CONTAMINATION IN AIRCRAFT INSTRUMENT REPAIR FACILITIES, 1966–1967. *Gail D. Schmidt, Jerome A. Halperin, Eric Geiger,* and *Walter Livingstone. Radiological Health Data and Reports, Vol. 12, January 1971,* pp. 7–15.

A survey of 30 aircraft instrument repair facilities revealed many cases of significant radium contamination, resulting from repair and dial stripping operations on radium luminous dial instruments. Five out of 15 facilities surveyed in Wichita, Kans. showed alpha contamination exceeding 200,000 dpm/100 cm^2, with a maximum of 1,650,000 dpm/100 cm^2. The direct gamma radiation ranged from background to 60 mR/h range. Whole body counts of 33 persons working in these facilities showed radium body burdens in two people that were about 40 percent of the maximum permissible body burden. A similar survey of 15 repair facilities in Dade County, Florida, showed lower alpha contamination levels by a factor of 10.

Based upon these findings, a radiation control program including contamination guides has been recommended for instrument repair facilities.

KEYWORDS: Radium, repair facilities, aircraft instruments.

ENVIRONMENTAL SURVEY OF URANIUM MILL TAILINGS PILE, MEXICAN HAT, UTAH. *Robert N. Snelling. Radiological Health Data and Reports, Vol. 12, January 1971,* pp. 17–28.

At the request of the Navajo Tribal Council through the PHS Division of Indian Health at Window Rock, Ariz., an environmental radiological survey was conducted on the A–Z Minerals Corporation uranium tailings pile, Mexican Hat, Utah, in May 1968. The purpose of the survey was to identify any radiation hazards which might exist and recommend methods for their control. The survey included evaluation of external gamma radiation and airborne and waterborne radioactivity.

The results of the survey indicate that the external radiation levels on the tailings area exceed recommended exposure limits for individuals in the general population. Therefore, the area should not be released for public use in its present state. Action which would permit the release of the area would involve covering the tailings with uncontaminated soil to an extent that would diminish the external radiation to an acceptable level and to stabilize the covering against wind erosion.

Radiation levels in air and water do not exceed recommended exposure limits. However, to minimize the possibility of increased activity from weather conditions different from those existing during the survey, it is recommended that the tailings be stabilized against wind erosion or periodic monitoring will be necessary.

KEYWORDS: Air, environmental survey, exposure limits, gamma radiation, mill tailings, uranium, Utah, water.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 12, Number 2, February 1971

Radiological Health Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

- Department of Defense
- Department of Agriculture
- Department of Commerce
- Department of Health, Education, and Welfare
- Environmental Protection Agency
- Atomic Energy Commission

CONTENTS

Page

Editorial 81

REPORTS

The Uptake of Cerium-144, Promethium-147, and Plutonium-238 by Oat Plants from Soils 83
S. L. Cummings and L. Bankert

DATA

SECTION I. MILK AND FOOD 87

Milk Surveillance, October 1970 87

Food and Diet Surveillance 96

1. Radionuclides in Institutional Diet Samples, July–September 1970 97

SECTION II. WATER 100

Radioactivity in Washington Surface Water, July 1968–June 1969 101

83

CONTENTS—continued

Page

SECTION III. AIR AND DEPOSITION 107

Radioactivity in Airborne Particulates and Precipitation 107

1. Radiation Alert Network, October 1970 108
2. Canadian Air and Precipitation Monitoring Program, October 1970 111
3. Pan American Air Sampling Program, October 1970, *PAHO* and *PHS* 112

SECTION IV. OTHER DATA 113

Environmental Levels of Radioactivity At Atomic Energy Commision Installations 113

1. Atomics International, January–June 1970 113
2. Neutron Devices Department, January–June 1970 116

Reported Nuclear Detonations, January 1971 118

Synopses iii

Guide for Authors .... Inside back cover

RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

Dr. Joseph A. Lieberman
Acting Commissioner
Radiation Office

BOARD OF EDITORIAL ADVISORS

Dr. Harold O. Wyckoff
Department of Defense
Dr. Milton W. Lammering
Environmental Protection Agency
Dr. Maurice H. Frere
Department of Agriculture
Dr. Carl O. Muehlhause
Department of Commerce
Robert E. Simpson
Department of Health, Education, and Welfare
Dr. Martin B. Biles
Atomic Energy Commission

STAFF

Editor	Samuel Wieder
Managing Editor	Kurt L. Feldmann
Editorial Assistants	Jacqueline J. Copp Mary Nesdore
Illustrator	Marylee Hill

Address correspondence to the Editor, *Radiological Health Data and Reports, Radiation Office*, 1901 Chapman Avenue, Rockville, Md. 20852.

For subscriptions to *Radiological Health Data and Reports*, please use the order form on last page of this issue.

ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

MISSION: ENVIRONMENTAL

The National Environmental Policy Act of 1969, Public Law 91-190, provides for the development of reports on governmental actions that may have impact on the environment, for the accumulation of data and other information for a continuing analysis of changes or trends, and for an interpretation of their underlying causes.

Radiological Health Data and Reports was established within the Department of Health, Education, and Welfare in response to a Presidential directive of 1959, providing for the collation, analysis, and interpretation of data on environmental radiation levels. Pursuant to Reorganization Plan No. 3 of 1970, these responsibilities were transferred to the Environmental Protection Agency.

Now in its twelfth year of publication, *Radiological Health Data and Reports* has served governmental agencies, scientific and technical communities, and the public as a qualified source of information in its field, and as a useful record of trends in environmental radiation and its impact on the population.

In projecting future directions for *Radiological Health Data and Reports*, we take into consideration the anticipated growth of nuclear power operations and related activities. We also recognize the interrelationship of all forms of environmental hazard. The role of this journal may well be enlarged to provide a continuing record of data that will help qualified investigators to evaluate the total impact of environmental hazards in a highly complex technological society.

Any future expanded role of *Radiological Health Data and Reports* will develop as we progress in formulating systematic procedures to correlate the findings of studies and surveys relating to ecological systems and environmental quality. In pursuit of these aims, the cooperation of investigators at all levels of government, and that of other involved organizations, will be sought.

We look forward to continued, responsible service in providing competent information about activities relating to the quality of the environment.

William D. Ruckelshaus

William D. Ruckelshaus
Administrator
Environmental Protection Agency

Reports

The Uptake of Cerium-144, Promethium-147, and Plutonium-238 by Oat Plants from Soils

S. L. Cummings and L. Bankert[1]

The uptakes of cerium-144, promethium-147, and plutonium-238 by oat plants were determined for nine soils, and promethium-147 and plutonium-238 uptakes were compared with cerium-144 uptake. The percentage uptake values for all three radionuclides were very low, ranging from 10^{-6} to 10^{-3} percent. Nitrogen and potassium fertilizers increased the uptake of promethium-147 by oat plants from an Amite soil. Because the amount of cerium-144, promethium-147, and plutonium-238 taken up by plants from soils is very small, the health hazards to man by the soil-plant-man pathway from these radionuclides will probably be negligible at the levels used in this study.

With the uses and proposed uses of radionuclides as heat sources in auxiliary space batteries, it is important to know to what extent these radionuclides will be taken up from soils by plants in the event a land area becomes contaminated from an abortive flight. Two radionuclides of interest for which very limited information is available on plant uptake from soils are promethium-147 and plutonium-238 (*1,2*).

Since sample preparation for counting plutonium-238 (primarily an alpha emitter) and promethium-147 (primarily a beta emitter) involves much more time than for gamma-emitting radionuclides and since the maximum permissible body burden of plutonium-238 is quite low, it would be advantageous to be able to relate promethium-147 and plutonium-238 uptake by plants from soils to some radionuclide, e. g., cerium-144, that is easily prepared for counting and much less hazardous to handle when performing plant uptake experiments. Therefore, the objectives of this study were to determine to what extent promethium-147 and plutonium-238 are taken up from different soils and to see if this uptake could be related to cerium-144 uptake.

Materials and methods

Properties and collection locations of the soils used in this investigation are given in table 1. One-pint plastic cottage cheese containers (80 cm² surface area) were used to contain the soils for the plant uptake experiments. The containers were partially filled with soil leaving approximately 1 cm of space at the top. The activity (100 μCi of cerium-144 chloride, 100 μCi of promethium-147 chloride, and 50 μCi of plutonium-238 nitrate solution) was uniformly applied to the

Table 1. Soil properties

Soil series	Cation exchange capacity (meq/100 g)	Organic matter (percent)	pH
Fox (Ohio)	9.15	2.7	7.3
Blanton (Florida)	2.62	2.7	5.4
Lakeland (Florida)	1.75	2.2	5.5
Adamsville (Florida)	3.02	1.3	5.9
Ruskin (Florida)	4.63	3.0	5.6
Leon (Florida)	1.53	6.1	5.5
Congaree (Alabama)	3.49	2.5	5.5
Ochlockonee (Alabama)	8.80	1.8	5.9
Amite (Alabama)	2.07	1.6	6.3

---

[1] Mr. Cummings and Mr. Bankert are with Environmental Protection Agency, Radiation Office, Southeastern Radiological Health Laboratory, P.O. Box 61, Montgomery, Ala. 36101.

soil surface of the partially filled container and additional soil added so that the activity was 1 cm below the soil surface (*3*). Each soil was replicated three times for each radionuclide. One soil (Amite) was used to determine the effect of nitrogen, phosphorus, and potassium on the uptake of promethium-147. Nitrogen, phosphorus, and potassium salts, separately and in combination, were thoroughly mixed with the soil. Thirty oat seeds (*Avena sativa* var. Suregrain) were planted in each container. Oats were chosen as an indicator crop because of their rapid growth and thinned to 20 plants after emergence. The containers were randomly placed in a controlled environment chamber maintained at day and night temperatures of 25° and 18° C, respectively, and day and night relative humidities of 62 and 75 percent, respectively, with a 14-hour photoperiod. Soil moisture tension was adjusted to 0.1 bar by daily watering. Shoots of all plants were collected 3 weeks after planting. Cerium-144 was determined by gamma spectroscopy on dried samples (70° C). Promethium-147 and plutonium-238 levels were determined with an internal proportional counter after the plants had been dry ashed. The soil cation exchange capacity, organic matter content, and pH (1:1 soil-water ratio) were determined by previously published procedures (*3,4*).

Results and discussion

The percentage uptakes of cerium-144, promethium-147, and plutonium-238 by oat plants from all soils were very low (table 2). Some of these values were as much as six orders of magnitude lower than strontium-85 and cesium-137 oat plant percentage uptakes from the same soils (*3*). The uptake of cerium-144 was greater than promethium-147 from six of the nine soils and greater than plutonium-238 from all nine soils. These results are in general agreement with previous work (*1,2*).

Table 2. Percentage uptake of cerium-144, promethium-147, and plutonium-238 by oat plants

Soil series	Percentage uptake[a]		
	Cerium-144 ($\times 10^{-4}$)	Promethium-147 ($\times 10^{-4}$)	Plutonium-238 ($\times 10^{-4}$)
Fox (Ohio)	[b]0.33 ±0.07	0.58 ±0.06	0.07 ±0.01
Blanton (Florida)	13.1 ±1.4	7.8 ±2.1	.10 ± .04
Lakeland (Florida)	14.6 ±1.7	10.5 ± .72	.61 ± .10
Adamsville (Florida)	2.56 ± .85	.92 ± .08	1.20 ± .37
Ruskin (Florida)	2.70 ± .16	.96 ± .13	.53 ± .24
Leon (Florida)	5.00 ± .33	2.76 ± .25	.40 ± .20
Congaree (Alabama)	26.5 ±2.9	33.9 ±3.6	2.2 ±1.1
Ochlockonee (Alabama)	8.7 ±1.9	8.92 ± .21	.33 ± .10
Amite (Alabama)	7.93 ± .80	5.54 ± .08	2.28 ± .56

[a] Percentage uptake is the ratio of the activity in all the plants to the total activity applied to the soil times 100.
[b] Plus or minus 1 standard deviation.

The linear correlation coefficient of promethium-147 uptake with respect to cerium-144 uptake was 0.95 and plutonium-238 uptake with respect to cerium-144 uptake was 0.47. The relationship between cerium-144 and promethium-147 is quite good and much better than the cerium-144 and plutonium-238 relationship. Although these results are for a limited number of soils, they can be used as a guide to future plant uptake studies with these radionuclides. Additional work with more soils will help verify these results.

An Amite soil was used to determine the effect of nitrogen, phosphorus, and potassium fertilizer salts on oat plant uptake of promethium-147 because of the limited amount of this type of information available for this radionuclide (*5*). The results are given in table 3. Nitrogen and potassium fertilization increased promethium-147 uptake while phosphorus had no significant effect. Nitrogen had a greater enhancing effect than did potassium for this particular soil.

Because the soil-to-plant as well as the food-to-man (*6*) transfer of these three radionuclides is very small, the possible health hazards to man from this pathway would likely be negligible

Table 3. The effect of nitrogen, phosphorus, and potassium on the percentage uptake of promethium-147 by oat plants from an Amite soil

Application rate (kg/hectare)			Percentage uptake[a] ($\times 10^{-4}$)	Plant weight (mg dry weight)
N	P	K		
0	0	0	[b]5.54 ±0.08	605
[c]560	0	0	10.6 ±1.1	649
0	0	[d]560	6.66 ± .66	590
[c]560	0	[d]560	17.6 ±2.8	709
[c]560	[e]560	0	9.4 ±1.1	712
0	[f]560	[d,f]560	4.83 ± .20	641
[c]560	[f]560	[d,f]560	17.3 ±2.4	701

[a] Percentage uptake is the ratio of the activity in all the plants to the total activity applied to the soil times 100,
[b] Plus or minus 1 standard deviation.
[c] Ammonium nitrate.
[d] Potassium chloride.
[e] Sodium dihydrogen phosphate.
[f] Potassium dihydrogen phosphate.

at the levels used in this study. This statement may not apply to root crops, which preliminary studies indicate may retain certain isotopes in greater concentrations than the above ground portion.[2]

REFERENCES

(*1*) RHODES, D. W. Adsorption of plutonium by soil. Soil Sci 84:465–471 (1957).

(*2*) NISHITA, H., et al. Uptake of radioactive fission products by crop plants. J Agr Food Chem 9:101–106 (1961).

(*3*) CUMMINGS, S. L., et al. ^{137}Cs uptake by oat plants as related to the soil fixing capacity. Health Phys 17:145–148 (1969).

(*4*) JACKSON, M. L. Soil chemical analysis. Prentice-Hall Publishers (1968).

(*5*) ALEKSAKHIR, R. M. Radioactive contamination of soil and plants. U.S. Atomic Energy Commission and the National Science Foundation (1965).

(*6*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendations of the International Commission on Radiological Protection, Report of Committee II on permissible dose for internal radiation (1959).

---

[2] Personal communication from the Southwestern Radiological Health Laboratory, January 14, 1971.

SECTION I. MILK AND FOOD

Milk Surveillance, October 1970

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Radiation Office, Environmental Protection Agency, and the Office of Compliance, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible

89

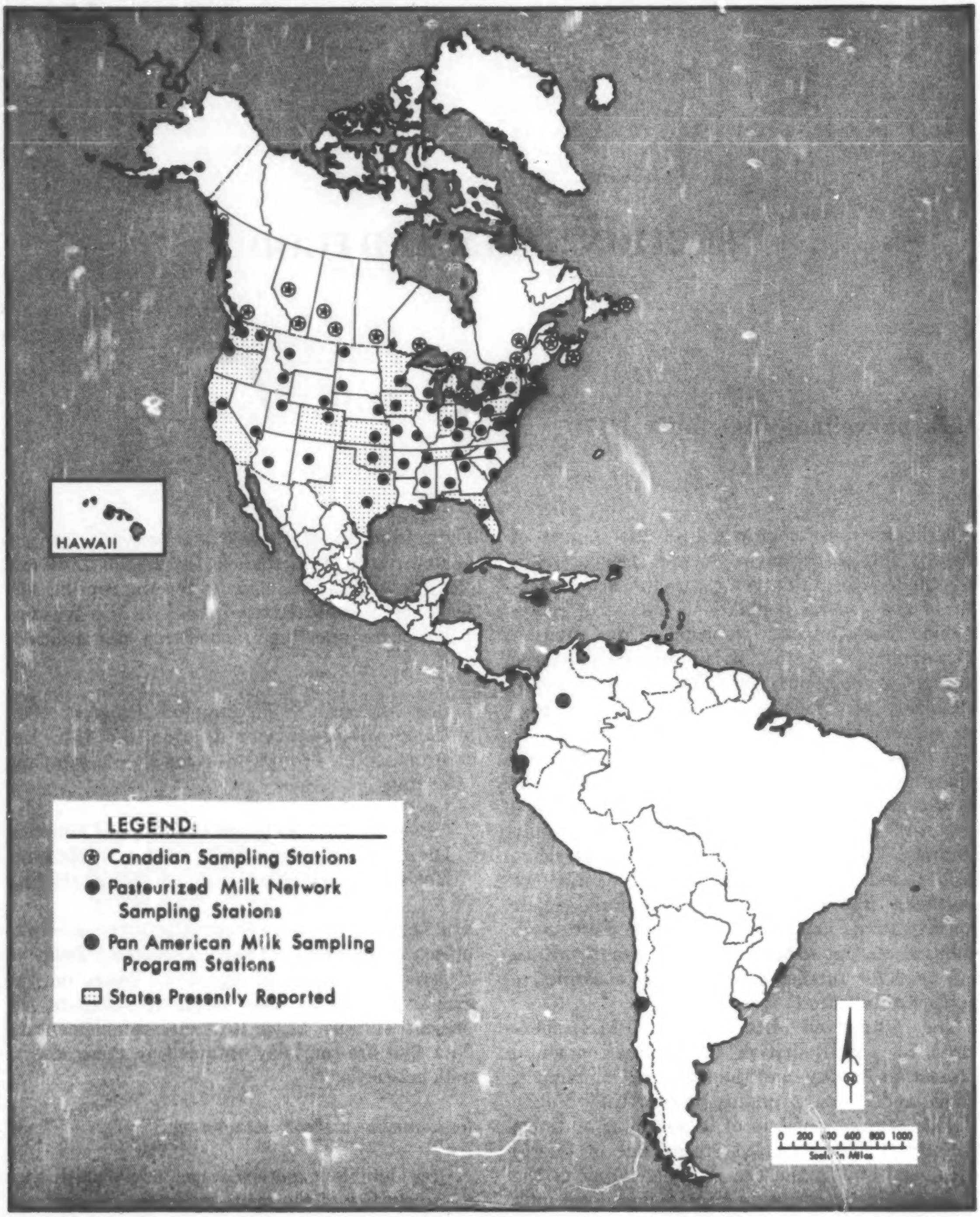

HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
● Pan American Milk Sampling Program Stations
▨ States Presently Reported
0 200 400 600 800 1000
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere

radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2-standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Radiation Office conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during May-July 1970, with 28 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 (*5*). Of the 20 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 13 participated in the experiment. The accuracy results of this experiment are shown in table 1. In general, considerable improvement is needed, especially in the accuracy measurements.

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category			
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Strontium-89: High (258 pCi/liter)	7 (44%)	1 (6%)	8 (50%)	16
Low (15 pCi/liter)	11 (69%)	3 (19%)	2 (12%)	16
Strontium-90: Intermediate (79.4 pCi/liter)	13 (57%)	4 (17%)	6 (26%)	23
Low (32.0 pCi/liter)	5 (25%)	4 (20%)	11 (55%)	20
Iodine-131: High (507 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
Low (40 pCi/liter)	16 (64%)	3 (12%)	6 (24%)	25
Cesium-137: High (259 pCi/liter)	20 (74%)	3 (11%)	4 (15%)	27
Low (53 pCi/liter)	17 (66%)	5 (19%)	4 (15%)	26
Barium-140: High (302 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
Low (33 pCi/liter)	23 (92%)	0	2 (8%)	25

[a] Measured concentration less than or equal to 2σ of the known concentration.
[b] Measured concentration greater than 2σ and less than or equal to 3σ of the known concentration.
[c] Measured concentration greater than 3σ of the known concentration.

These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short time periods, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. An analysis of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentrations of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels are given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environment conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the

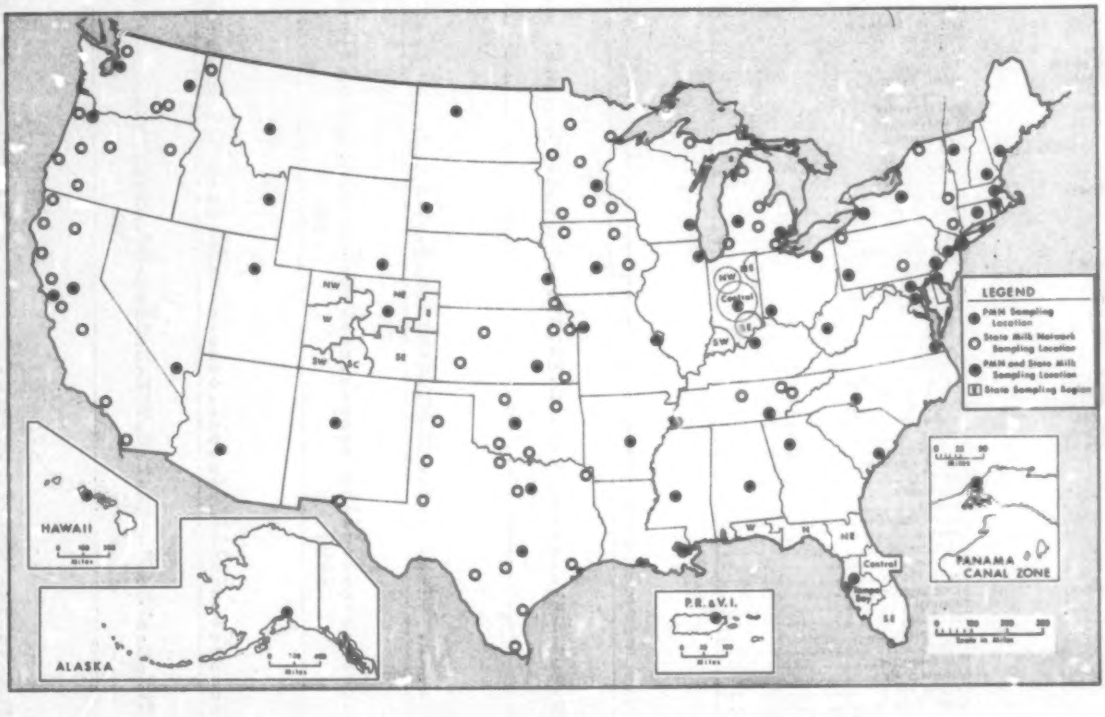


Figure 2. State and PMN milk sampling stations in the United States

Table 2. Concentrations of radionuclides in milk for October 1970 and 12-month period November 1969 through October 1970

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	10	6	0	0	18	10
Alaska:	Palmer[c]	P	6	6	0	0	24	9
Ariz:	Phoenix[c]	P	2	1	0	0	0	0
Ark:	Little Rock[c]	P	11	13	0	0	12	17
Calif:	Sacramento[c]	P	2	2	0	0	0	0
	San Francisco[c]	P	3	2	0	0	0	0
	Del Norte	P	17	17	0	0	5	18
	Fresno	P	2	2	0	0	3	2
	Humboldt	P	4	5	0	0	0	5
	Los Angeles	P	2	2	0	0	0	2
	Mendocino	P	2	3	0	0	0	3
	Sacramento	P	3	3	0	0	0	2
	San Diego	P	1	2	0	0	0	1
	Santa Clara	P	2	2	0	0	0	1
	Shasta	P	3	3	0	0	0	2
	Sonoma	P	3	2	0	0	1	3
Colo:	Denver[c]	P	4	5	0	0	0	1
	West	R	([illegible])		•0 (4)	1	•0 (4)	4
	Northeast	R	([illegible])		•0 (6)	0	•0 (6)	0
	East	R	([illegible])		•0	0	•0	0
	Southeast	R	([illegible])		NS	0	NS	0
	South Central	R	([illegible])		NS	0	NS	7
	Southwest	R	([illegible])		NS	0	NS	0
	Northwest	R	([illegible])		0	0	•0	0
Conn:	Hartford[c]	P	7	8	0	0	0	12
	Central	P	7	7	0	0	21	14
Del:	Wilmington[c]	P	8	9	0	0	11	7
D.C:	Washington[c]	P	5	7	0	0	12	7
Fla:	Tampa[c]	P	5	6	0	0	55	51
	West	R	10	9	0	0	10	17
	North	R	9	11	0	0	46	25
	Northeast	R	9	7	0	0	49	36
	Central	R	8	7	0	0	43	40
	Tampa Bay area	R	6	6	0	0	49	40
	Southeast	R	12	8	0	0	111	73
Ga:	Atlanta[c]	P	10	10	0	0	15	17
Hawaii:	Honolulu[c]	P	4	2	0	0	0	0
Idaho:	Idaho Falls[c]	P	7	5	0	0	0	4
Ill:	Chicago[c]	P	6	7	0	0	16	10
Ind:	Indianapolis[c]	P	9	8	0	0	14	7
	Northeast	P	9	9	0	1	10	14
	Southeast	P	11	11	0	0	15	12
	Central	P	8	9	0	1	15	10
	Southwest	P	12	12	0	0	10	12
	Northwest	P	10	10	0	0	10	15
Iowa:	Des Moines[c]	P	9	7	0	0	11	2
	Iowa City	P	9	7	0 (2)	0	12 (2)	11
	Des Moines	P	8	8	0 (3)	0	9 (3)	7
	Spencer	P	7	6	0	0	15	5
	Fredericksburg	P	NS	NS	NS	NS	NS	NS
Kans:	Wichita[c]	P	6	8	0	0	0	2
	Coffeyville	P	8	10	0	0	0	0
	Dodge City	P	0	8	0	1	0	1
	Falls City	P	NS	14	NS	0	NS	2
	Hays	P	17	14	0	1	12	1
	Kansas City	P	14	10	0	0	0	3
	Topeka	P	18	12	0	0	12	3
	Wichita	P	30	12	0	0	0	0
Ky:	Louisville[c]	P	8	8	0	0	12	5
La:	New Orleans[c]	P	12	15	0	0	15	19
Maine:	Portland[c]	P	8	10	0	0	26	23
Md:	Baltimore[c]	P	7	7	0	0	0	8
Mass:	Boston[c]	P	9	10	0	0	17	21
Mich:	Detroit[c]	P	7	8	0	0	0	9
	Grand Rapids[c]	P	10	9	0	0	14	12
	Bay City	P	7	7	•0	•0	0	9
	Charlevoix	P	9	13	•0 (2)	•0	12 (2)	16
	Detroit	P	6	8	•0	•0	12	7
	Grand Rapids	P	7	9	•0	•0	0	9
	Lansing	P	9	9	•0 (2)	•0	7 (2)	14
	Marquette	P	8	14	•0 (2)	•0	21 (2)	23
	Monroe	P	4	6	•0 (2)	•0	0 (2)	4
	South Haven	P	9	8	•0 (4)	•0	0 (4)	6
Minn:	Minneapolis[c]	P	10	10	0	0	13	9
	Bemidji	P	10	10	0	0	26	23
	Mankato	P	7	8	0	0	0	11
	Rochester	P	7	6	0	0	0	11
	Duluth	P	13	14	0	0	20	26
	Worthington	P	3	4	0	0	0	0
	Minneapolis	P	10	9	0	0	14	15
	Fergus Falls	P	7	6	0	0	16	12
	Little Falls	P	16	10	0	0	27	31

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for October 1970 and 12-month period November 1969 through October 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
Miss:	Jackson[c]	P	9	12	0	0	16	12
Mo:	Kansas City[c]	P	7	8	0	0	0	2
	St. Louis[c]	P	9	9	0	0	13	4
Mont:	Helena[c]	P	6	5	0	0	0	6
Nebr:	Omaha[c]	P	0	5	0	0	0	1
Nev:	Las Vegas[c]	P	4	2	0	0	0	0
N.H:	Manchester[c]	P	10	8	0	0	23	19
N.J:	Trenton[c]	P	8	8	0	0	11	9
N.Mex:	Albuquerque[c]	P	3	3	0	0	0	0
N.Y:	Buffalo[c]	P	8	7	0	0	15	9
	New York City[c]	P	8	10	0	0	11	16
	Syracuse[c]	P	7	7	0	0	0	10
	Albany	P	11	6	0 (4)	0	0 (4)	0
	Buffalo	P	NS	0	0	0	0	0
	Massena	P	4	7	0	0	20	0
	Newburg	P	8	7	0 (3)	0	0 (3)	0
	New York City	P	9	8	0	0	0	0
	Syracuse	P	•0	3	0	0	0	0
N.C:	Charlotte[c]	P	12	11	0	0	0	13
N.Dak:	Minot[c]	P	11	10	0	0	12	14
Ohio:	Cincinnati[c]	P	6	8	0	0	0	4
	Cleveland[c]	P	7	9	0	0	11	9
Okla:	Oklahoma City[c]	P	7	6	0	0	0	5
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Oreg:	Portland[c]	P	5	6	0	0	0	5
	Baker	P	NA	4	•0	•0	17	5
	Coos Bay	P	NA	6	•0	•0	18	14
	Eugene	P	NA	3	•0	•0	•0	4
	Medford	P	NA	3	•0	•0	•0	8
	Portland composite	P	NA	0	•0 (2)	•0	19 (2)	8
	Portland local	P	NA	5	•0 (3)	•0	12 (3)	6
	Redmond	P	NA	3	•0	•0	•0	3
	Tillamook	P	NA	6	•0	•0	24	16
Pa:	Philadelphia[c]	P	8	9	0	0	0	5
	Pittsburgh[c]	P	10	11	0	0	12	12
	Dauphin	P	NS	7	NS	4	NS	11
	Erie	P	NS	11	NS	0	NS	28
	Philadelphia	P	9	8	0	3	13	14
	Pittsburgh	P	18	12	0	1	22	19
R.I:	Providence[c]	P	7	9	0	0	20	16
S.C:	Charleston[c]	P	6	10	0	1	13	19
S.Dak:	Rapid City[c]	P	NA	7	NS	0	NS	5
Tenn:	Chattanooga[c]	P	9	9	0	0	0	10
	Memphis[c]	P	7	8	0	0	0	7
	Chattanooga	P	8	12	0	0	18	16
	Clinton	P	10	14	0 (2)	1	20 (2)	16
	Fayetteville	P	NS	12	NS	0	NS	10
	Knoxville	P	5	9	0	0	10	9
	Nashville	P	6	9	0	0	18	9
Tex:	Austin[c]	P	0	2	0	0	0	3
	Dallas[c]	P	4	6	0	0	0	6
	Amarillo	R	NS	4	NS	0	NS	2
	Corpus Christi	R	NS	4	NS	0	NS	2
	El Paso	R	NS	3	NS	0	NS	0
	Fort Worth	R	3	5	0	0	0	0
	Harlingen	R	NS	3	NS	0	NS	0
	Houston	R	4	5	0	0	20	14
	Lubbock	R	NS	4	NS	0	NS	0
	Midland	R	0	2	0	0	0	0
	San Antonio	R	NS	4	NS	0	NS	0
	Texarkana	R	NS	8	NS	0	NS	0
	Tyler	R	NS	15	NS	0	NS	17
	Uvalde	R	NS	7	NS	0	NS	0
	Wichita Falls	R	NS	9	NS	0	NS	5
Utah:	Salt Lake City[c]	P	4	4	0 (2)	0	8 (2)	6
Vt:	Burlington[c]	P	6	8	0	0	14	12
Va:	Norfolk[c]	P	8	9	0	0	0	9
Wash:	Seattle[c]	P	6	6	0	0	16	8
	Spokane[c]	P	5	6	0	0	0	1
	Benton County	R	NS	0	NS	0	NS	5
	Franklin County	R	0	1	0	0	0	3
	Sandpoint, Idaho	R	13	10	0	0	23	22
	Skagit County	R	5	6	0	0	0	7
W.Va:	Charleston[c]	P	8	8	0	0	0	5
Wisc:	Milwaukee[c]	P	5	6	0	0	13	11
Wyo:	Laramie[c]	P	6	5	0	0	0	1

See footnotes at end of table.

95

Table 2. Concentrations of radionuclides in milk for October 1970 and 12-month period November 1969 through October 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA:								
Alberta:	Calgary	P	NA		NA		17	17
	Edmonton	P	NA		NA		23	18
British Columbia:	Vancouver	P	NA		NA		21	26
Manitoba:	Winnipeg	P	NA		NA		26	25
New Brunswick:	Fredericton	P	NA		NA		23	21
Newfoundland:	St. John's	P	NA		NA		29	35
Nova Scotia:	Halifax	P	NA		NA		24	20
Ontario:	Ottawa	P	NA		NA		12	13
	Saulte Ste. Marie	P	NA		NA		27	32
	Thunder Bay	P	NA		NA		27	27
	Toronto	P	NA		NA		0	9
	Windsor	P	NA		NA		8	10
Quebec:	Montreal	P	NA		NA		12	18
	Quebec	P	NA		NA		25	26
Saskatchewan:	Regina	P	NA		NA		15	14
	Saskatoon	P	NA		NA		17	13
CENTRAL AND SOUTH AMERICA:								
Colombia:	Bogota	P	0	0	0	0	0	0
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Kingston	P	NS	4	NS	0	NS	57
Venezuela:	Caracas	P	3	1	0	0	0	0
Canal Zone:	Cristobal[c]	P	0	1	0	0	13	9
Puerto Rico:	San Juan[c]	P	NA	3	NS	0	NS	8
PMN Network average[f]			7	7	0	0	8	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parenthesis.

[c] EPA Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

Strontium—90: New York—3 pCi/liter

[f] This entry gives the average radionuclide concentrations for the EPA Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90, iodine-131, and cesium-137 for October 1970 and the 12-month period, November 1969 through October 1970. Except where noted the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for October 1970 were below the respective practical reporting levels. The following station averages reflect samples in which strontium-89 and barium-140 were detected: strontium-89; Mo., St. Louis (PMN) 7 pCi/liter; Colombia, Bogata (PAHO), 10 pCi/liter; Chile, Santiago (PAHO) 10 pCi/liter; barium-140; Kans., Hays (State) 13 pCi/liter, Wichita (State) 11 pCi/liter.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council, levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 30 pCi/liter in the United States for October 1970, and the highest 12-month average was 17 pCi/liter (Del Norte, Calif.) representing 8.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 111 pCi/liter in the United States for October 1970, and the highest 12-month average was 73 pCi/liter (southeast Florida), representing 2.0 percent of the guide determined by using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica. Iodine-131 results for individual samples were all below the practical reporting level.

Acknowledgement

Appreciation is expressed to the personnel of the following health agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiological Health Section
Division of Air, Occupational and
Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational
Health Section
Department of Health and Rehabilitative
Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Nuclear Engineering
New York State Department of
Environmental Conservation

Division of Occupational and Radiological
Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

REFERENCES

(1) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Public Health 49:225 (February 1959).

(2) Chart of the Nuclides, Ninth Edition revised to July 1966. Knolls Atomic Power Laboratory (November 1966).

(3) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

(4) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(5) KNOWLES, F. Interlaboratory study of iodine-131, cesium-137, barium-140, strontium-89, and strontium-90 measurements in milk, May–July 1970, Technical experiment 70-MKAQ-1. Analytical Quality Control Service, Bureau of Radiological Health (September 1970).

(6) NEILL, R. H. and D. R. SNAVELY. State Health Department sampling criteria for surveillance of radioactivity in milk. Radiol Health Data Rep 8:621–627 (November 1967).

(7) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

(8) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER, and B. KAHN. The cause of relatively high cesium-137 concentrations in Tampa, Florida, milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiological Health Data and Reports* are as follows.

Program	Period	Issue
California Diet Study	April–December 1969 and January–June 1970	November 1970
Connecticut Standard Diet	July–December 1969	December 1970
Institutional Diet Samples	April–June 1970	January 1971
Strontium-90 in Tri-City Diets, *HASL*	June–December 1969	June 1970

1. Radionuclides in Institutional Diet Samples July–September 1970

Bureau of Radiological Health and
Food and Drug Administration

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Bureau of Radiological Health with the assistance of the Office of Compliance, Food and Drug Administration (*1*).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. At the present time, 18 basic institutions and eight auxiliary institutions, distributed geographically as shown in figure 1, are being sampled. The station at St. Louis, Mo., was discontinued because of difficulty in locating a new institution. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1, 2*). Consequently, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev; the Southeastern Radiological Health Laboratory, Montgomery, Ala; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sam-

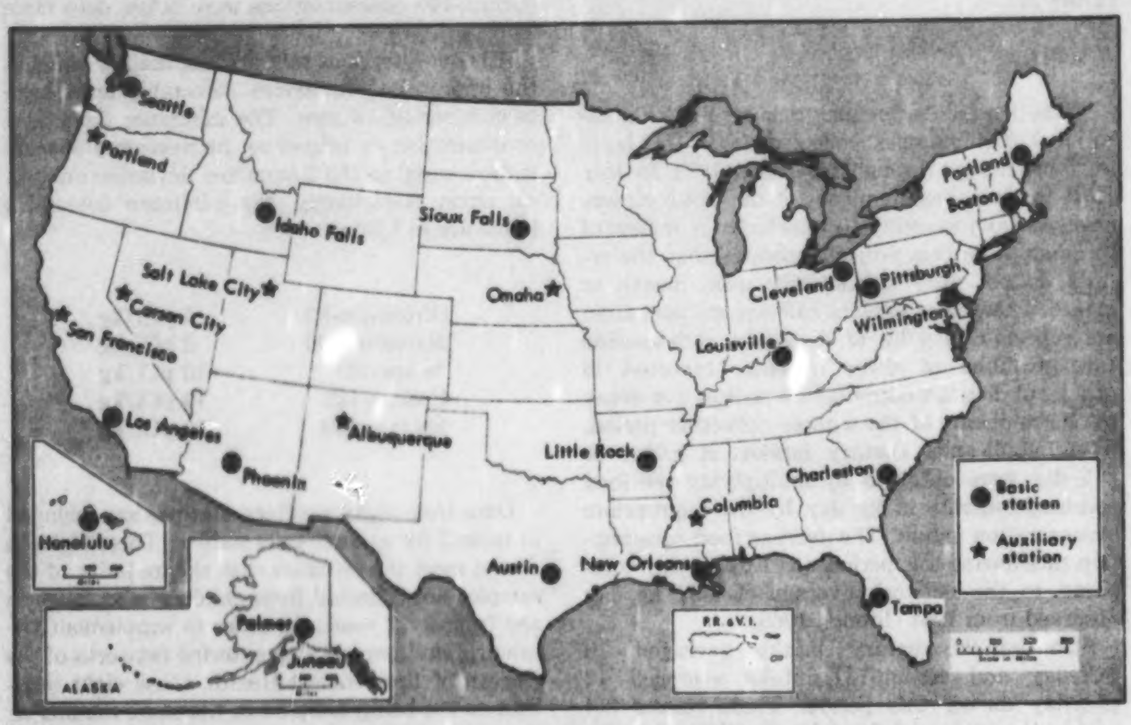

Seattle
Portland
Idaho Falls
Sioux Falls
Salt Lake City
Carson City
San Francisco
Omaha
Los Angeles
Phoenix
Albuquerque
Little Rock
Austin
New Orleans
Columbia
Charleston
Tampa
Louisville
Cleveland
Pittsburgh
Wilmington
Portland
Boston
Honolulu
Palmer
Juneau
ALASKA
P.R. & V.I.
Basic station
Auxiliary station
Scale in Miles

Figure 1. Institutional diet sampling locations as of September 1970

Table 1. Concentrations and intake of stable elements and radionuclides in institutional total diets of children (9–12 years of age), July–September 1970

Location of institution		Month (1970)	Total weight (kg/day)	Calcium		Potassium		^{89}Sr		^{90}Sr		^{137}Cs	
				(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska:	Palmer	July	1.04	0.4	0.4	1.6	1.6	0	0	3	3	21	22
Ariz:	Phoenix	Aug	1.49	.3	.4	1.6	2.4	0	0	4	6	0	0
Ark:	Little Rock	July	1.11	.7	.7	1.6	1.7	0	0	11	12	12	13
Calif:	Los Angeles	July[a]	1.46	.6	.8	1.1	1.6	0	0	3	4	0	0
Del:	Wilmington	July	2.21	1.1	2.5	1.4	3.1	NA	NA	6	12	0	0
Fla:	Tampa	July	[b].96	.3	.3	1.4	1.4	0	0	5	5	36	35
Hawaii:	Honolulu	July	2.17	.4	.9	1.4	3.0	0	0	2	5	0	0
Idaho:	Idaho Falls	July[a]	2.12	1.9	4.0	1.6	3.4	0	0	7	15	14	30
Ky:	Louisville	July	2.27	.7	1.5	1.5	3.5	0	0	8	19	0	0
La:	New Orleans	July[a]	[b].90	.3	.3	1.1	1.1	0	0	3	3	0	0
Maine:	Portland	July	1.41	1.6	2.2	1.5	2.1	NA	NA	11	16	21	30
Mass:	Boston	July	2.07	1.2	2.5	1.6	3.3	0	0	7	14	14	29
Ohio:	Cleveland	July	1.68	1.3	2.0	1.5	2.4	NA	NA	9	15	13	21
Pa:	Pittsburgh	Aug[a]	2.34	.5	1.2	1.5	3.5	NA	NA	6	14	12	28
S.C:	Charleston	July	1.71	.5	.8	1.1	1.9	0	0	7	11	0	0
S. Dak:	Sioux Falls	Sept[a]	1.17	.8	1.0	1.8	2.1	NA	NA	7	8	11	13
Texas:	Austin	July[a]	1.60	.7	1.0	1.5	2.2	0	0	3	5	0	0
Wash:	Seattle	July[a]	2.28	.5	1.2	1.4	3.3	0	0	3	7	0	0
Network average			1.67	0.8	1.3	1.5	2.4	0	0	6	10	9	12

[a] Food samples were collected from two or more children who were not between the ages of 9 and 12.
[b] Milk was not included in this sample.
NA, no analysis.
NOTE: Iodine-131 and barium-140 were not detected at any station during this period.

pling and analytical procedures was presented earlier (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from the basic stations for July through September 1970. In July 1970, the sampling frequency of this network was changed from monthly to quarterly. A review of the data from this project indicates that the results do not vary significantly from month to month. The stable elements, calcium and potassium are reported in g/kg of diet. The radionuclide concentrations of these samples, reported in pCi/kg of diet, are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.67 kg/day compared to the network average of 1.87 kg/day observed from 1961 through 1969.

Strontium-90 dietary intake averaged 10 pCi/day and cesium-137 intake averaged 12 pCi/day during this period. These results fall within Range I as defined by the Federal Radiation Council (*4*). Strontium-89, iodine-131, and barium-140 concentrations were below detectable levels.

All concentrations that are less than or equal to the appropriate minimum detectable level have been reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2-standard deviation analytical error. Accordingly, the minimum detectable limits are as follows:

Strontium-89	5 pCi/kg
Strontium-90	2 pCi/kg
Iodine-131	10 pCi/kg
Cesium-137	10 pCi/kg
Barium-140	10 pCi/kg

Data from eight auxiliary stations are included in table 2 for general information. These stations do not meet the criterion that the majority of the samples are collected from children who range in age from 9–12 years. In order to supplement the existing environmental monitoring networks of the Bureau of Radiological Health, these eight institutions are being sampled in the same manner as the basic stations.

100

Table 2. Concentrations and intake of stable elements and radionuclides in institutional total diets of individuals (auxiliary stations), July–September 1970

Location of Institution		Month (1970)	Total weight (kg/day)	Calcium		Potassium		^{89}Sr		^{90}Sr		^{137}Cs	
				(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska:	Juneau	Aug	1.42	0.2	0.3	1.5	2.1	0	0	4	6	32	45
Calif:	San Francisco	July	1.01	.6	1.1	1.5	2.8	0	0	0	0	0	0
Miss:	Columbia	July	2.33	1.1	2.6	1.5	3.5	0	0	8	18	27	63
Nebr:	Omaha	July	1.48	1.5	2.2	1.6	2.4	NA	NA	6	9	0	0
Nev:	Carson City	July	1.41	.9	1.3	1.5	2.1	0	0	5	7	23	33
N. Mex:	Albuquerque	July	1.90	.7	1.3	1.2	2.2	0	0	4	8	0	0
Oreg:	Portland	July	1.94	.6	1.1	1.7	3.3	0	0	3	6	14	27
Utah:	Salt Lake City	Aug	2.10	.5	1.0	1.4	3.0	0	0	2	5	0	0
Network average			1.81	0.8	1.4	1.5	2.7	0	0	4	7	12	21

NA, no analysis
NOTE: Iodine-131 and barium-140 were not detected at any station during this period.

REFERENCES

(1) ANDERSON, E. C. and D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(2) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Radiol Health Data 6:548–554 (October 1965).

(3) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1968. Radiol Health Data Rep 9:557–566 (October 1968).

(4) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
October–December 1969 and Annual Summary 1969	August 1970
January–March 1970	November 1970
April–June 1970	January 1971

SECTION II. WATER

The Environmental Protection Agency, the Federal Water Quality Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	July–December 1968	August 1970
Minnesota	January–June 1969	January 1970
New York	January–June 1969	June 1970
Kansas	January–December 1969	September 1970
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, *HASL*	January–December 1969	July 1970
Tritium in Surface Water	January–June 1970	November 1970
Washington	July 1967–June 1968	June 1969

---

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Radioactivity in Washington Surface Water[1] July 1968-June 1969

Washington State Department of Social and Health Services

Radioanalysis of surface water samples collected throughout the State is one of the major functions of the Washington State Department of Social and Health Services radiation surveillance program. Most surface water samples are collected monthly or quarterly by the Washington State Department of Ecology. Selected stations on the Columbia River are sampled weekly or monthly by local health departments. Cedar River, a major water supply for the greater Seattle area, is sampled monthly by the City of Seattle Water Department.

All water is collected in 2-liter polyethylene bottles by grab sampling and is mailed to the State radiation laboratory in Seattle for analysis. Before sampling, 2 milliliters of concentrated nitric acid are added to each bottle to prevent loss of radioactivity through precipitation or adhesion.

Analytical procedures

Surface water samples are analyzed for gamma-ray emitters and then separated into suspended and soluble fractions for gross beta counting. All Columbia River samples are also analyzed for phosphorus-32, a pure beta-particle emitter which is not detectable in the gamma-ray scan. Table 1

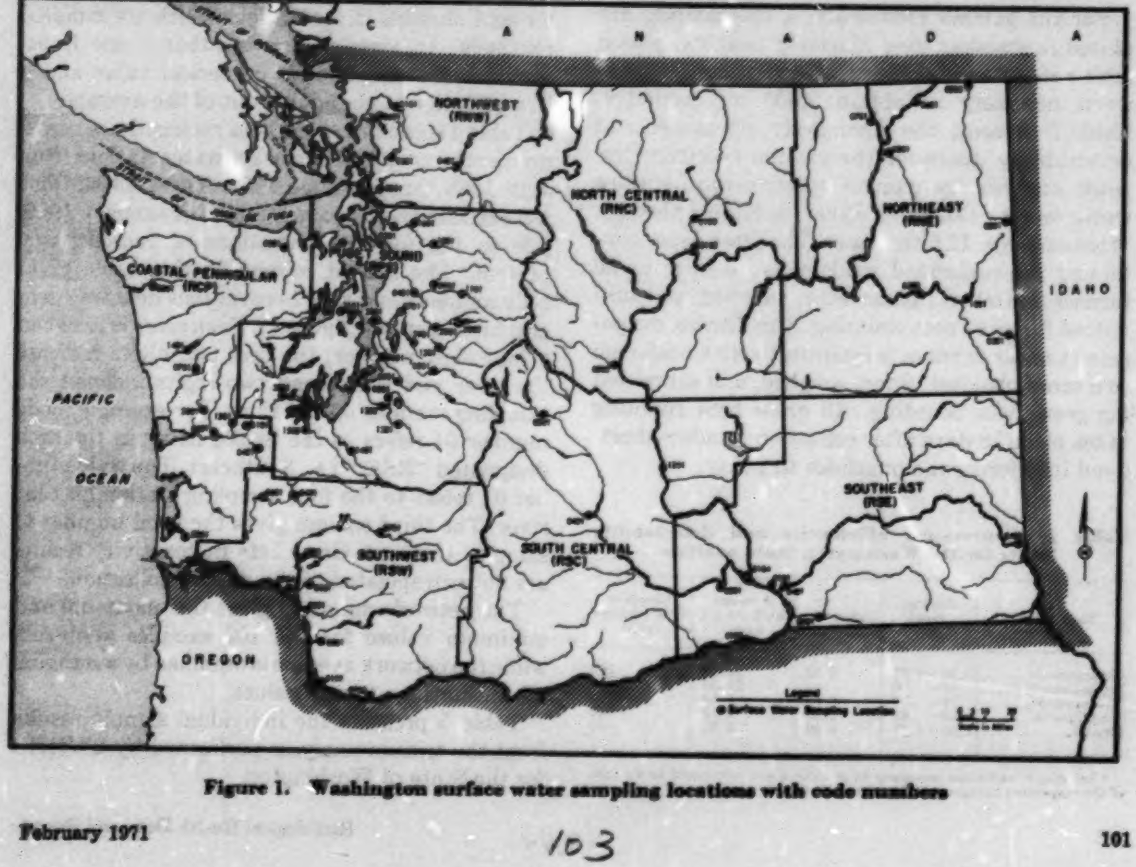

C A N A D A
NORTHWEST (RNW)
NORTH CENTRAL (RNC)
NORTHEAST (RNE)
COASTAL PENINSULAR (RCP)
IDAHO
PACIFIC
OCEAN
SOUTHWEST (RSW)
SOUTH CENTRAL (RSC)
SOUTHEAST (RSE)
OREGON
Legend
Surface Water Sampling Location

Figure 1. Washington surface water sampling locations with code numbers

gives the beta-particle efficiencies and detectability limits for the beta counters. When tritium analysis is desired for selected samples, a 24 ml aliquot of the sample is forwarded to the Environmental Protection Agency's Southwestern Radiological Health Laboratory (SWRHL) for processing.

---

[1] Summarized from "Environmental Radiation Surveillance in Washington State," Eighth Annual Report, July 1968-June 1969.

Table 1. Beta-particle efficiencies and detectability limits for the Washington State analysis

Radionuclide	Efficiency (percent)	Average background (cpm)	Limits of detectability[a] (pCi)
Wide Beta I[b]			
Strontium-yttrium-90	34	0.5	0.31
Yttrium-90	38	.5	.28
Phosphorus-32	35	.5	.30
Wide Beta II[c]			
Strontium-yttrium-90	47	.8	.25
Yttrium-90	51	.8	.23
Phosphorus-32	48	.8	.24

[a] Amount of radiation necessary to produce a net cpm equal to 2 sigma of background, based on 100 minute counts.
[b] The Wide Beta I suffered a major breakdown in March.
[c] The Wide Beta II radiation counter went into operation in April.

For the gamma radioanalysis, the samples are placed in stainless steel Marinelli beakers as soon after receipt as possible. Distilled water is added when necessary to obtain 2,000 ml geometry. Table 2 presents the gamma-ray efficiencies and detectability limits for the gamma spectrometer. After analysis by gamma spectroscopy, surface water (except Columbia River) is filtered through Whatman No. 42 filter paper. The filter paper containing the suspended solids is ashed in a muffle furnace at 600° C., plancheted, weighed, and submitted for gross beta counting. The filtrate, evaporated to near dryness, is quantitatively transferred to a tared planchet, dried, weighed, and submitted for gross beta counting. All gross beta counting takes place 18 days after collection to allow short-lived interfering radionuclides to decay.

Table 2. Gamma-ray efficiencies and detectability limits for the Washington State analysis

Radionuclide	Energy band (MeV)	Efficiency (percent)	Average background (cpm)	Limits of detectability[a] (pCi)
Chromium-51	0.30 – 0.36	0.52	22.79	200
Ruthenium-106	.44 – .56	.91	21.65	100
Zirconium-95	.73 – .79	6.96	5.59	10
Scandium-46	.86 – .92	2.45	4.73	20
Zinc-65	1.05 – 1.17	1.06	6.30	40

[a] Amount of radiation necessary to produce a net cpm equal to 4 sigma of the respective background, based on 100-minute counts.

The gamma analysis of the Columbia River samples is started approximately 14 days after collection. After the gamma spectroscopic analysis, Columbia River samples are divided into two aliquots. One aliquot is prepared for standard gross beta counting as described above, while the second aliquot is prepared for phosphorus-32 counting. The technique used for phosphorus-32 separation is a modification of published methods (*1–4*). After a waiting period of 18 days following collection to allow arsenic-76 and other short-lived interfering radionuclides to decay, the phosphorus is separated from the interfering radionuclides by precipitation as ammonium phosphomolybdate from an acid medium. The precipitate is washed with ammonium nitrate, dissolved with 3N ammonium hydroxide, transferred into a tared planchet, dried, ashed at 450°C., weighed, and counted for beta radioactivity.

Results

Table 3 presents the monthly average results for six Columbia River stations which are sampled routinely. In averaging, a less-than value is assumed to be equal to its numerical value and a less-than sign is placed in front of the average.

Table 4 summarizes the beta radioactivity measurements from 23 other surface water stations from July 1968 through June 1969. These 23 stations were reduced to 5 active stations in January 1969, due to the low concentrations of radioactivity present. The second column in this table gives code numbers and the abbreviations denoting geographical sections (figure 1). Each river is assigned a four digit number; the first two digits indicate the river and the second two digits indicate the sampling stations on the river. For example, code number 04 refers to the Snake River in the area designated "RSE," i.e., Southeast. The code number 01 refers to the first sampling station on that river. The third column gives the total number of samples analyzed. Gross beta radioactivity results are not extrapolated to the date of collection.

The network summary gives the maximum and minimum values for the 107 samples analyzed, while the network average is obtained by averaging all the station average values.

Table 5 presents the individual sample results from the tritium analyses performed by SWRHL for the State of Washington.

Table 3. Monthly average radioactivity in Columbia River water, July 1968–June 1969

Location and type of analysis	Concentration (pCi/liter)											
	1968						1969					
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Northport (code no. RNE 0601)												
Beta-particle												
Suspended[a]	NS	<1	NS	NS	<1	NS	NS	1	NS	NS	<1	NS
Dissolved[a]	NS	2	NS	NS	2	NS	NS	3	NS	NS	2	NS
Total	NS	<3	NS	NS	<3	NS	NS	4	NS	NS	<3	NS
Phosphorus-32[b]	NS	NA	NS	NS	<1	NS	NS	<1	NS	NS	<1	NS
Gamma-ray[b]												
Chromium-51	NS	<100	NS	NS	<100	NS	NS	<100	NS	NS	<100	NS
Ruthenium-106[c]	NS	<50	NS	NS	<50	NS	NS	<50	NS	NS	<50	NS
Zirconium-95	NS	<5	NS	NS	<5	NS	NS	<5	NS	NS	<5	NS
Zinc-65	NS	<20	NS	NS	<20	NS	NS	<20	NS	NS	<20	NS
Scandium-46	NS	<10	NS	NS	<10	NS	NS	<10	NS	NS	<10	NS
Richland (code no. RNE 0104)												
Beta-particle												
Suspended[a]	108(2)	NA	98(2)	181(2)	19(2)	138(2)	NS	725	66(3)	100(3)	34(4)	947(5)
Dissolved[a]	40(2)	NA	81(2)	101(2)	91(2)	129(2)	NS	162	157(3)	74(3)	47(4)	133(5)
Total[a]	148	NA	179	282	110	267	NS	887	223	174	81	1,080
Phosphorus-32[b]	30	33	101(2)	118(3)	101(2)	176(2)	NS	114	205(3)	54(3)	15(4)	130(5)
Gamma-ray[b]												
Chromium-51	1,201(3)	988	2,064(2)	3,266(2)	3,012(2)	3,100(2)	NS	1,450(3)	1,730(5)	724(3)	<205(3)	<3,090(5)
Ruthenium-106[c]	<100(3)	<100	<100(2)	<140(2)	<100(2)	<100(2)	NS	<100(3)	<100(5)	<100(3)	<100(4)	<100(5)
Zirconium-95	<10(3)	<10	<10(2)	<10(2)	<10(2)	<10(2)	NS	<10(3)	<10(5)	<10(2)	<15(4)	<13(5)
Zinc-65	113(3)	<40	119(2)	<155(2)	88(2)	139(2)	NS	218(3)	192(5)	107(2)	<61(4)	<460(5)
Scandium-46	<168(3)	35	193(2)	<316(2)	46(2)	507(2)	NS	215(3)	248(5)	108(3)	<84(4)	1,230(5)
Pasco (code no. RNE 0101)												
Beta-particle												
Suspended[a]	8	NA	41	40	19	25	27	22	NA	NS	16	12
Dissolved[a]	14	NA	72	52	97	66	78	66	NA	NS	14	24
Total[a]	22	NA	113	92	116	91	105	88	NA	NS	30	36
Phosphorus-32[b]	16	NA	80	70	121	93	72	94	99	NS	7	23
Gamma-ray[b]												
Chromium-51	182	1,800	1,680	1,520	3,330	1,860	1,030	1,040	497	NS	<100	206
Ruthenium-106[c]	<50	<50	<50	<50	<50	<50	<50	<50	<50	NS	<50	<50
Zirconium-95	<5	<5	<5	<5	<5	<5	<5	<5	<5	NS	<5	<5
Zinc-65	<20	57	47	51	96	77	73	80	58	NS	<20	25
Scandium-46	<10	86	73	64	70	81	74	62	67	NS	45	29
McNary Dam (code no. RNE 0102)												
Beta-particle												
Suspended[a]	14	NA	13	18	9	19	14	NA	17	NS	8	18
Dissolved[a]	13	NA	28	24	23	43	38	NA	47	NS	14	19
Total	27	NA	41	42	32	62	52	NA	64	NS	22	37
Phosphorus-32[b]	22	26	35	28	28	56	45	NA	71	NS	11	17
Gamma-ray[b]												
Chromium-51	510	570	856	660	560	1,040	808	572	574	NS	<100	242
Ruthenium-106[c]	<50	<50	<50	<50	<50	<50	<50	<50	<50	NS	<50	<30
Zirconium-95	<5	<5	<5	<5	<5	<5	<5	<5	<5	NS	<5	<5
Zinc-65	23	<20	22	<20	<20	40	40	42	54	NS	43	35
Scandium-46	22	13	19	26	25	86	38	25	35	NS	<10	26
Vancouver (code no. RSW 0102)												
Beta-particle												
Suspended[a]	7(3)	3	2(3)	4(2)	3(2)	9(3)	8(2)	15	10	11(2)	NS	9(3)
Dissolved[a]	9(3)	7	9(3)	12(3)	10(2)	15(3)	15(2)	21	22	19(2)	NS	11(3)
Total	16	10	12	16	13	24	23	36	32	30	NS	20
Phosphorus-32[b]	9(3)[a]	4	7(3)	10(2)	8(2)	18(3)	17	28	25	21(3)	NS	10(3)
Gamma-ray[b]												
Chromium-51	353(3)	230	446(3)	496(2)	309(2)	531(3)	406(2)	495(2)	304	270(2)	NS	<244(3)
Ruthenium-106[c]	<50(3)	<50	<50(3)	<50(2)	<50(2)	<50(3)	<50(2)	<50(2)	<30	<50(2)	NS	<50(3)
Zirconium-95	<5(3)	<5	<5(3)	<5(2)	<5(2)	<5(3)	<5(2)	<5(2)	<5	<5(2)	NS	<5(3)
Zinc-65	<20(3)	<20	<20(3)	<20(2)	<20(2)	<20(3)	<26(2)	25(3)	46	<20(2)	NS	<23(3)
Scandium-46	<15(3)	<10	<10(4)	<10(2)	<10(2)	<20(3)	20(2)	33(3)	13	18(2)	NS	<10(3)
Longview (code no. RSW 0604)												
Beta-particle												
Suspended[a]	5(5)	2(2)	2(4)	2(5)	2(4)	1(4)	2(4)	NA	5(2)	6(5)	6(4)	6(4)
Dissolved[a]	8(5)	6(2)	7(4)	7(5)	3(4)	3(4)	5(4)	NA	14(2)	11(5)	10(4)	6(4)
Total	13	8	9	9	5	4	7	NA	19	17	16	12
Phosphorus-32[b]	7(5)	3	4(4)	5(5)	2(4)	3(4)	3	NA	16	11(5)	11(4)	5(4)
Gamma-ray[b]												
Chromium-51	245(5)	215(4)	327(4)	377(5)	<142(4)	<135(4)	<115(4)	210(3)	240(4)	<155(5)	<142(4)	<119(4)
Ruthenium-106[c]	<50(5)	<50(4)	<50(4)	<50(5)	<50(4)	<50(4)	<50(4)	<50(3)	<50(4)	<50(5)	<50(4)	<50(4)
Zirconium-95	<5(5)	<5(4)	<5(4)	<5(5)	<5(4)	<5(4)	<5(4)	<5(3)	<5(4)	<5(5)	<5(4)	<5(4)
Zinc-65	<22(5)	<20(4)	<20(4)	<20(5)	<20(4)	<20(4)	<20(4)	<20(3)	<20(4)	<22(5)	<24(4)	<20(4)
Scandium-46	<10(4)	<10(4)	<10(4)	<10(5)	<10(4)	<10(4)	<10(4)	<13(3)	<11(4)	<11(5)	<11(4)	<10(4)

[a] Activity at time of counting. Strontium-90-yttrium-90-calibration standard.
[b] Results extrapolated to date of sample collection.
[c] Net activity in the 0.44-0.66 MeV gamma-range is assumed to be only ruthenium-106.
NS, no sample reported. NA, no analysis.

105

Table 4. Beta radioactivity in Washington surface water (except for Columbia River), July 1968–June 1969

Sampling location	Code number	Number of samples	Concentrations (pCi/liter)								
			Suspended			Dissolved			Total		
			Average[a]	Minimum	Maximum	Average[a]	Minimum	Maximum	Average[a]	Minimum	Maximum
Cedar River	RPS 0201	12	<1	<1	<1	<1	<1	1	1	<1	2
Lake Whatcom	RNW 0801	12	<1	<1	<1	2	2	3	3	3	4
Lewis River	RSW 0801	6	<1	<1	<1	<1	<1	<1	1	<1	1
Naches River	RSC 0401	6	<1	<1	<1	<1	<1	<1	1	<1	1
Naselle River	RCP 2201	5	<1	<1	<1	<1	<1	1	1	<1	2
Nisqually River	RPS 1401	2	<1	<1	<1	<1	<1	1	1	<1	2
Nooksack River	RNW 0101	2	9	<1	17	2	1	3	11	2	20
Okanogan River	RNC 0103	3	<1	<1	<1	2	2	2	3	3	3
Pend Oreille River	RNE 0201	3	<1	<1	<1	2	2	2	3	3	3
Puyallup River	RPS 1302	12	1	<1	3	1	<1	3	2	<1	5
Skagit River	RNW 0201	6	<1	<1	<1	1	<1	2	2	<1	3
Snake River	RSE 0401	7	<1	<1	1	3	2	4	4	3	5
	RSE 0402	2	<1	<1	<1	4	4	4	5	5	5
Snohomish River	RPS 0401	2	<1	<1	<1	1	1	1	2	2	2
Satsop River	RCP 1201	2	<1	<1	<1	<1	<1	<1	1	<1	1
Spokane River	RNE 0302	9	<1	<1	2	2	1	3	3	2	4
Sultan River	RPS 0951	1	<1			1			2		
Tolt River	RPS 2001	2	<1	<1	1	<1	<1	1	1	<1	2
Toutle River	RSW 0201	2	<1	<1	<1	<1	<1	1	1	<1	2
Walla Walla River	RSE 0501	2	<1	<1	1	6	4	9	7	5	10
Wishkah River	RCP 2001	5	<1	<1	<1	<1	<1	1	1	<1	2
Wenatchee River	RNC 0202	2	<1	<1	<1	<1	<1	1	1	<1	2
Yakima River	RSC 0201	2	<1	<1	<1	<1	<1	<1	1	<1	1
Network summary		107	<1	<1	17	1.3	<1	9	2.4	<1	20

[a] For averaging purposes, <1 is assumed to be equal to 0.5 pCi/liter.

Table 5. Tritium in Washington surface water,[a] July 1968–June 1969

Sampling location	Code number	Collection date	Concentration (nCi/liter)
Cedar River	RPS 0201	2/14/1969	0.47
		5/22/1969	<.40
Columbia River:			
Longview	RSW 0904	8/14/1968	1.70
		11/6/1968	.50
		2/14/1969	<.40
		5/7/1969	.88
McNary Dam	RSE 0102	8/12/1968	1.40
		11/13/1968	.46
		2/18/1969	.95
		5/20/1969	.85
Pasco	RSE 0101	2/5/1969	1.30
		5/5/1969	.96
Richland	RSE 0104	2/17/1968	.71
		5/5/1969	1.10
Richland (treated)		5/5/1969	1.00
Vancouver	RSW 0102	8/26/1968	.92
		11/4/1968	.92
		2/3/1969	.70
Lake Whatcom	RNW 0801	8/6/1968	1.10
		11/19/1968	1.00
		2/11/1969	.87
		5/12/1969	.56
Lewis River	RSW 0801	8/13/1968	.55
		11/12/1968	.60
Puyallup River	RPS 1302	9/11/1968	<.40
		11/18/1968	<.40
		2/10/1969	<.40
		5/14/1969	<.40
Skagit River	RNW 0201	8/6/1968	1.10
		11/19/1968	.52
Snake River	RSE 0401	2/18/1969	.84
		5/20/1969	.75
Snohomish River	RPS 0401	9/10/1968	1.40
Spokane River	RNE 0302	8/11/1968	1.40
		11/11/1968	.92
		2/2/1969	.65
		5/18/1969	.65
Toutle River	RSW 0201	10/21/1968	.50

[a] Analyses performed by SWRHL, Las Vegas, Nev.

Discussion

Of the 107 river water samples analyzed from July 1968 through June 1969 (excluding the Columbia River), the total beta radioactivity ranged from <1 to 20 pCi/liter with an average of 2.4 pCi/liter. The radioactivity of the suspended fraction ranged from <1 to 17 pCi/liter with an average of <1 pCi/liter. The radioactivity of the soluble fraction was approximately the same, ranging from <1 to 9 pCi/liter and averaging 1.3 pCi/liter. These network averages during the July 1968 through June 1969 period were lower than the averages for the preceding 12 months. Figure 2 shows the annual average gross beta radioactivity in surface waters other than the Columbia River.

Monthly average total beta radioactivity for the Columbia River stations below the Hanford Facility ranged from 4 to 1,080 pCi/liter. Monthly average concentrations of the beta-particle emitter, phosphorus-32, in the Columbia River water samples taken below the Hanford Facility, ranged from 2 to 205 pCi/liter. Figures 3 and 4 show the gross beta and phosphorus-32 results from the Columbia River at Pasco and Vancouver for 1965 through 1969.

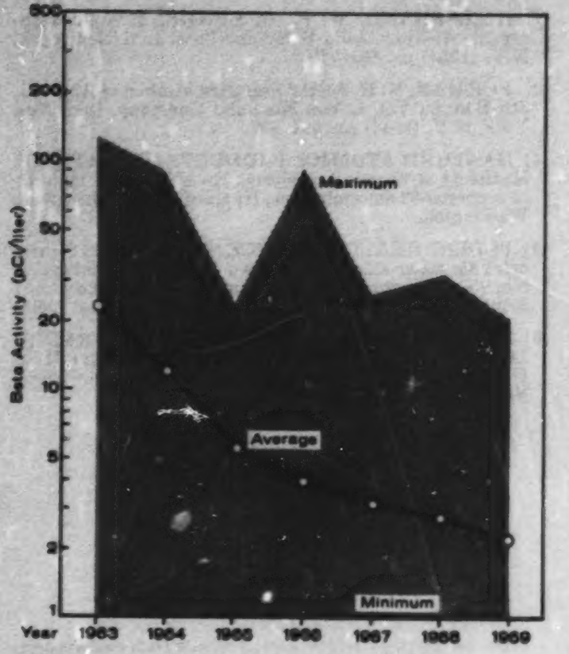


Figure 2. Average, maximum, and minimum beta radioactivity in surface water (excluding the Columbia river) 1963–1969

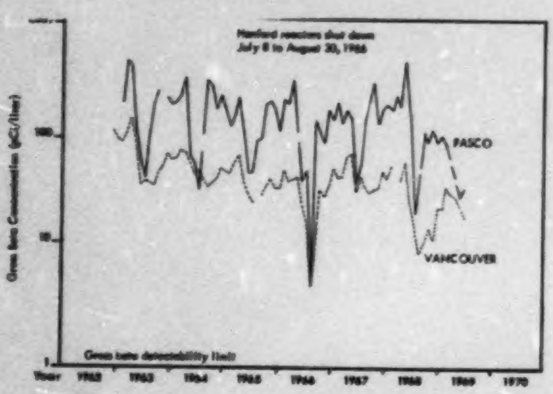


Figure 3. Gross beta in Columbia River water Pasco and Vancouver

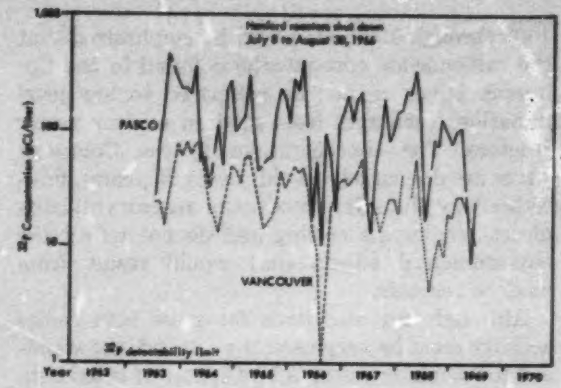


Figure 4. Phosphorus-32 in Columbia River water Pasco and Vancouver

The gamma-ray emitters, ruthenium-106 and zirconium-95, were found in monthly average concentrations that ranged from <50 to <140 pCi/liter for ruthenium-106 and <5 to <13 pCi/liter for zirconium-95. The values for ruthenium-106 were probably a combination of ruthenium-103 and ruthenium-106. Two other radionuclides, chromium-51 and zinc-65, were found in detectable quantities in Columbia River water. Monthly averages for chromium-51 ranged from <100 to <3,990 pCi/liter, and for zinc-65 the range was <20 to 460 pCi/liter. Figures 5 and 6 show the results for chromium-51 and zinc-65 at the Pasco and Vancouver stations on the Columbia River for

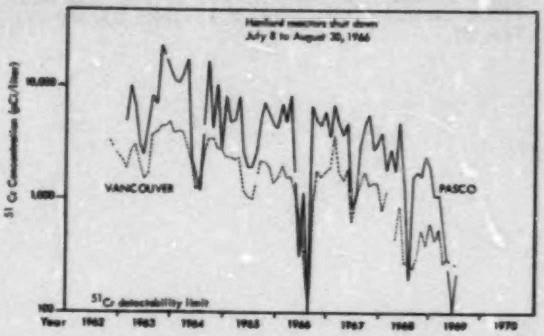


Figure 5. Chromium-51 in Columbia River water Pasco and Vancouver

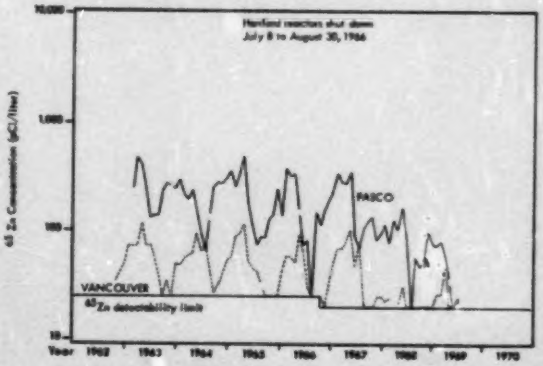


Figure 6. Zinc-65 in Columbia River water Pasco and Vancouver

107

1963 through 1969. It should be emphasized that the radionuclide concentrations found in the Columbia River cannot be compared to low level radiation discharges from modern nuclear power reactors. The concentrations in the Columbia River are due largely to old (up to 25 years), first-technology plutonium production reactors utilizing direct, single-pass cooling and do not reflect the environmental effects that would result from modern reactors.

Although any standards for gross beta radioactivity must be very carefully applied, the standard for drinking water is 1 nCi/liter of gross beta radioactivity in the absence of strontium-90 and alpha emitters (*5*). The standards for water from all dietary sources for the general population at large (*6*) are: chromium-51, 670 nCi/liter; ruthenium-106, 3.3 nCi/liter; zinc-65, 10 nCi/liter; phosphorus-32, 7 nCi/liter.

REFERENCES

(*1*) KALTHOFF and SANDELL. Textbook of Quantitative Inorganic Analysis, Revised Edition. The MacMillan Company, New York, N.Y. (1949) pp. 390–397; 713–717.

(*2*) HILLEBRAND, W. F., G. LUNDELL. Applied Inorganic Analysis. John Wiley and Sons, Inc., New York, N.Y. (1953) pp. 694–710.

(*3*) FURMAN, N. H. Scotts' Standard Method of Analysis, 5th Edition, Vol. 1. Van Nostrand Company, Inc., New York, N.Y. (1944) pp. 694–697.

(*4*) HANFORD ATOMICS PRODUCTS OPERATIONS. Radiological ch[illegible] analysis: River analysis manual-phosphorus-32 determination, Hanford Facility, Richland, Washington.

(*5*) PUBLIC HEALTH SERVICE. Public Health Service drinking water standards, revised 1962. PHS Publication No. 956, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (August 1963).

(*6*) INTERNATIONAL COMMISSION OF RADIOLOGICAL PROTECTION. Report of Committee II on Permissible Dose for Internal Radiation. Pergamon Press, New York, N.Y. (1959).

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
July 1967–June 1968	June 1969

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
Fallout in the United States and Other Areas, *HASL*	January–June 1968	October 1969
Plutonium in Airborne Particulates and Precipitation, *PHS*	April–December 1969	October 1970

109

1. Radiation Alert Network
October 1970

Air Pollution Control Office
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State Health Department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Air Pollution Control Office officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Data Acquisition and Analysis Branch, Division of Air Quality and Emission Data, Air Pollution Control Office, EPA, Cincinnati, Ohio. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during October 1970. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

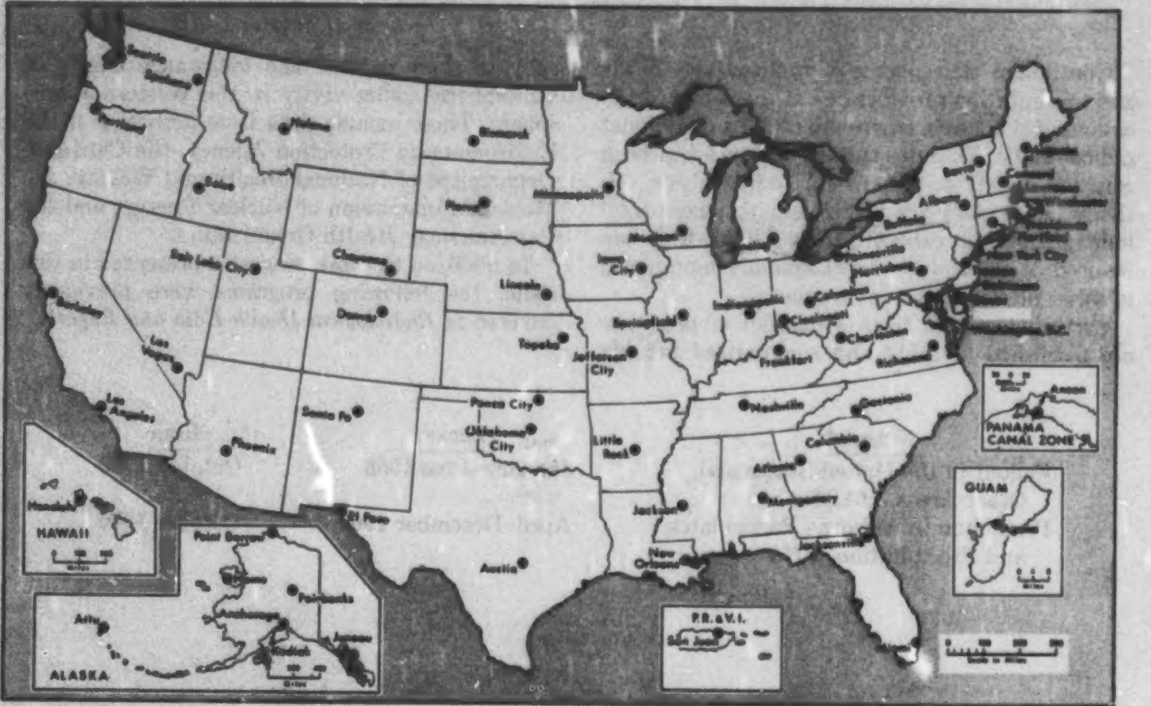

Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Salt Lake City
Cheyenne
Lincoln
Berkeley
Denver
Topeka
Las Vegas
Jefferson City
Los Angeles
Ponca City
Santa Fe
Oklahoma City
Phoenix
El Paso
Austin
Little Rock
Honolulu
HAWAII
Point Barrow
Fairbanks
Anchorage
Attu
Kodiak
Juneau
ALASKA
Madison
Iowa City
Springfield
Indianapolis
Columbus
Cincinnati
Frankfort
Charleston
Harrisburg
Buffalo
Albany
Concord
New York City
Washington, D.C.
Richmond
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Jackson
New Orleans
Jacksonville
Ancon
PANAMA CANAL ZONE
GUAM
P.R. & V.I.
San Juan

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, October 1970

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Last profile in RHD&R	Number of samples	Precipitation			
								Total depth samples (mm)	Field estimation of deposition		
			Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	21	5	0	1	Oct 70	5	163	5	163	55
Alaska:	Anchorage	1	0	0	0	Feb 71	0				
	Attu Island	30	0	0	0	Nov 70	0				
	Fairbanks	16	1	0	0	July 70	9	41	9	41	30
	Juneau	1	10	10	10	Aug 70	0				
	Kodiak	1	0	0	0	Sept 70	0				
	Nome	30	3	0	1	Dec 70	0				
	Point Barrow	0				Nov 70	0				
Ariz:	Phoenix	7	14	3	5	Aug 70	0				
Ark:	Little Rock	7	4	0	1	June 70	0				
Calif:	Berkeley	21	2	0	1	Sept 70	3	20	3	20	1
	Los Angeles	21	4	0	1	Dec 70	0				
C.Z:	Ancon	4	0	0	0	Sept 70	0				
Colo:	Denver	19	7	0	2	Sept 70	3	15	(b)		
Conn:	Hartford	21	2	0	1	July 70	6	59	5	53	2
Del:	Dover	21	2	0	0	Feb 71	0				
D.C:	Washington	25	1	0	0	Dec 70	0				
Fla:	Jacksonville	21	2	0	1	June 70	4	24	4	24	2
	Miami	11	0	0	0	July 70	6	93	6	93	0
Ga:	Atlanta	21	2	1	1	Jan 71	1	95	1	95	25
Guam:	Agana	0				Feb 71	0				
Hawaii:	Honolulu	25	3	0	1	Nov 70	4	15	(b)		
Idaho:	Boise	33	5	0	2	Nov 70	6	29	6	29	0
Ill:	Springfield	3	1	1	1	Dec 70	0				
Ind:	Indianapolis	21	2	0	1	Jan 71	0				
Iowa:	Iowa City	20	2	0	1	Sept 70	3	40	3	40	0
Kans:	Topeka	32	3	0	1	June 70	6	56	6	56	7
Ky:	Frankfort	7	1	0	1	Dec 70	0				
La:	New Orleans	20	1	0	0	Aug 70	7	114	(b)		
Maine:	Augusta	21	3	0	1	Jan 71	5	65	5	65	0
Md:	Baltimore	21	2	0	1	July 70	4	24	4	24	0
Mass:	Lawrence	20	3	0	1	Sept 70	5	73	5	73	0
	Winchester	21	5	0	1	Oct 70	5	61	5	61	0
Mich:	Lansing	21	3	0	1	Nov 70	8	91	8	91	9
Minn:	Minneapolis	21	2	0	1	Feb 71	5	163	5	163	10
Miss:	Jackson	17	1	0	0	Aug 70	5	364	4	302	17
Mo:	Jefferson City	21	3	0	1	Jan 71	8	102	8	102	0
Mont:	Helena	21	4	1	1	Oct 70	0				
Nebr:	Lincoln	17	6	0	2	Jan 71	4	118	4	118	23
Nev:	Las Vegas	20	3	1	1	July 70	0				
N.H:	Concord	0				Dec 70	0				
N.J:	Trenton	20	3	0	1	Aug 70	4	78	4	78	7
N.Mex:	Santa Fe	17	3	0	1	Oct 70	3	24	3	24	1
N.Y:	Albany	0				Jan 71	2	42	2	42	9
	Buffalo	19	1	0	0	Sept 70	0				
	New York City	0				Oct 70	0				
N.C:	Gastonia	17	14	1	5	Sept 70	4	62	(b)		
N. Dak:	Bismarck	21	6	1	2	Dec 70	5	17	5	17	4
Ohio:	Cincinnati	0				Feb 71	0				
	Columbus	2	2	2	2	Aug 70	0				
	Painesville	19	2	0	1	July 70	0	119	10	119	21
Okla:	Oklahoma City	16	5	0	1	Nov 70	2	84	2	84	0
	Ponca City	21	3	0	2	July 70	6	45	6	45	6
Oreg:	Portland	18	2	0	1	Jan 71	7	80	7	80	2
Pa:	Harrisburg	13	2	0	1	Feb 71	1	23	1	23	4
P.R:	San Juan	0				Aug 70	0				
R.I:	Providence	21	5	0	1	Nov 70	2	19	2	19	1
S.C:	Columbia	23	5	0	1	Oct 70	2	80	2	80	3
S. Dak:	Pierre	17	8	1	4	Aug 70	0				
Tenn:	Nashville	15	2	0	1	Nov 70	6	101	6	101	6
Tex:	Austin	0				Feb 71	0				
	El Paso	2	5	2	4	Dec 70	0				
Utah:	Salt Lake City	20	7	0	2	Jan 71	5	25	4	18	0
Vt:	Barre	10	4	0	2	June 70	4	34	4	34	5
Va:	Richmond	22	2	0	1	June 70	4	36	4	36	21
Wash:	Seattle	13	1	0	0	June 70	8	64	(b)		
	Spokane	0				Feb 71	0				
W. Va:	Charleston	21	4	0	1	Oct 70	7	94	7	94	11
Wis:	Madison	22	2	0	1	June 70	7	55	7	55	4
Wyo:	Cheyenne	20	10	0	2	July 70	4	29	4	29	4
Network summary		1,009	14	0	1		210	80	5	71	8

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.

[b] This station is part of the plutonium in precipitation network. No gross beta measurements are done.

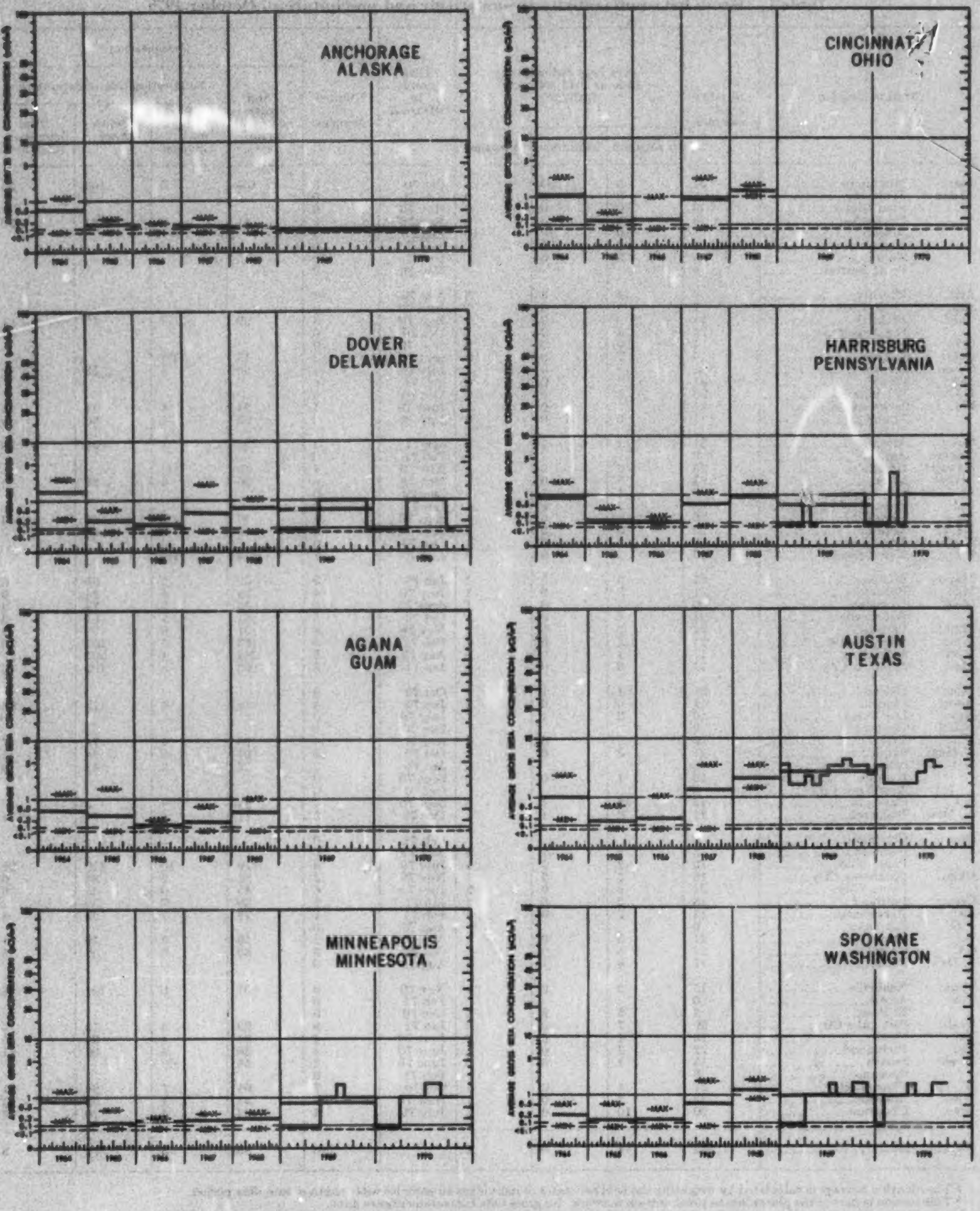


Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1964–October 1970

2. Canadian Air and Precipitation Monitoring Program[1], October 1970

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for October 1970 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, October 1970

Station	Number of samples	Gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	9	0.2	0.1	0.1	NS	NS
Coral Harbour	NS				NS	NS
Edmonton	12	.2	.0	.1	22	0.9
Ft. Churchill	12	.1	.0	.1	13	1.3
Fredericton	11	.3	.0	.1	18	6.2
Goose Bay	11	.3	.0	.1	NS	NS
Halifax	12	.2	.1	.1	33	3.8
Inuvik	4	.1	.0	.1	39	1.7
Montreal	5	.1	.0	.1	15	3.0
Moosonee	12	.2	.0	.1	27	.9
Ottawa	11	.1	.0	.1	28	1.8
Quebec	11	.2	.0	.1	33	3.7
Regina	14	.2	.0	.1	31	1.0
Resolute	3	.1	.1	.1	44	2.1
St. John's, Nfld	12	.1	.0	.1	21	3.2
Saskatoon	10	.1	.0	.1	20	6.0
Sault Ste. Marie	12	.1	.0	.1	28	2.3
Thunder Bay	11	.2	.0	.1	36	6.1
Toronto	3	.1	.1	.1	37	3.0
Vancouver	4	.1	.1	.1	33	2.3
Whitehorse	11	.1	.0	.1	70	3.5
Windsor	11	.1	.0	.1	37	1.7
Winnipeg	11	.2	.0	.1	50	1.5
Yellowknife	7	.1	.0	.1	54	1.1
Network summary	219	0.3	0.0	0.1	34	2.7

NS, no sample.

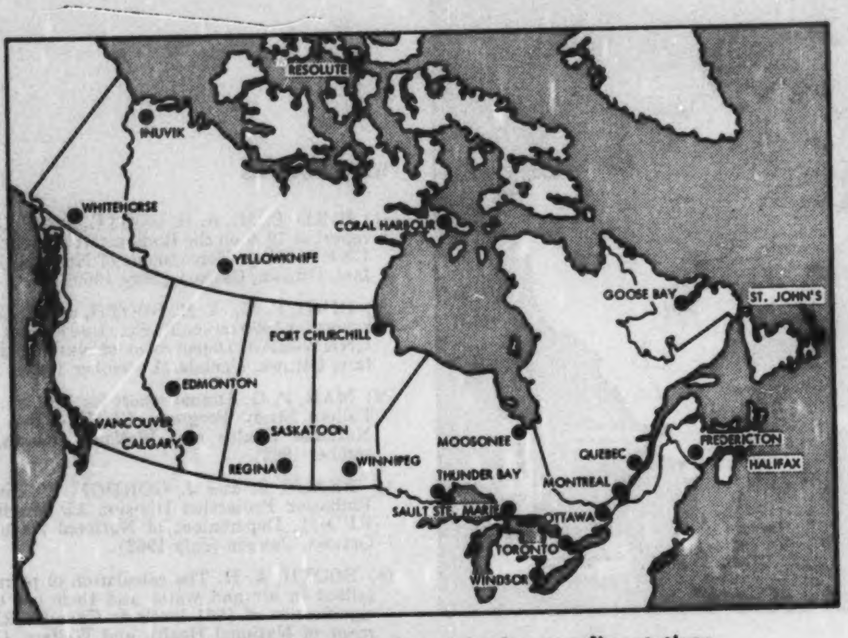

RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

---

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Air Sampling Program October 1970

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 4. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The October 1970 air monitoring results from the participating countries are given in table 3.

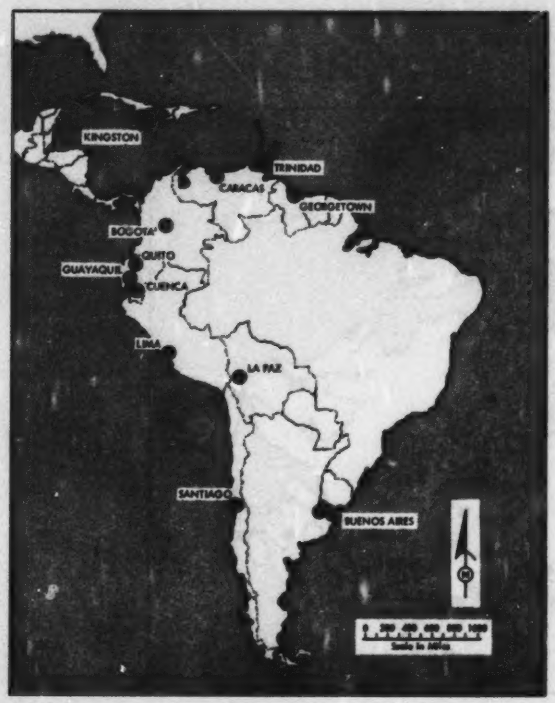


Table 3. Summary of gross beta radioactivity in Pan American surface air, October 1970

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina	Buenos Aires	NS	NS	NS	NS
Bolivia:	La Paz	20	1.13	0.10	0.40
Chile:	Santiago	5	.45	.14	.29
Colombia:	Bogota	20	.10	.00	.03
Ecuador:	Cuenca	NS	NS	NS	NS
	Guayaquil	NS	NS	NS	NS
	Quito	NS	NS	NS	NS
Guyana:	Georgetown	14	.10	.01	.10
Jamaica:	Kingston	NS	NS	NS	NS
Peru:	Lima	26	1.04	.03	.45
Venezuela:	Caracas	12	.24	.03	.09
West Indies:	Trinidad	16	.20	.00	.07
Pan American summary		112	1.13	0.00	0.24

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Reported values of less than 0.005 pCi/m³ are considered as 0.00 pCi/m³ in averaging.

NS, no sample.

REFERENCES

(1) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(4) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(5) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are data such as those obtained from human bone sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Atomics International and Neutron Devices Department.

1. Atomics International[2]
January–June 1970

North American Rockwell Corporation
Canoga Park, California

Atomics International, a division of North American Rockwell Corporation, has engaged in atomic energy research and development since 1946. The company designs, develops, and constructs nuclear reactors for central station and compact power plants for medical, industrial, and scientific applications.

The company headquarters is located in Canoga Park, Calif., approximately 23 miles northwest of downtown Los Angeles. The 290-acre Nuclear Development Field Laboratory (Santa Susana Facility), equipped with extensive testing facilities for the support of advanced nuclear studies, is located in the Simi Hills of Ventura County, approximately 29 miles northwest of downtown Los Angeles. The location of the above sites in relation to nearby communities is shown in figure 1.

The basic concept of radiological hazard control at Atomics International requires adequate containment of radioactive materials and, through rigid operational controls, minimizes effluent releases and external radiation levels. The environmental monitoring program provides a measure of the effectiveness of the company's radiological safety procedures and of engineering safeguards incorporated into facility designs.

The onsite environs of Atomics International headquarters and Nuclear Development Field Laboratory (NDFL) are surveyed monthly to determine the concentration of radioactivity in typical surface soil, vegetation, and water samples. The offsite environs are sampled monthly, except for soil and vegetation which are sampled quarterly. In addition, continuous environmental air monitoring at the sites provides information concerning long-lived airborne particulate radioactivity.

Air monitoring

Environmental air sampling is conducted continuously at the headquarters and NDFL sites

---

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

[2] Summarized from "Environmental Monitoring, Semiannual Report, January 1, 1970 to June 30, 1970" Atomics International, Division of North American Rockwell Corporation.

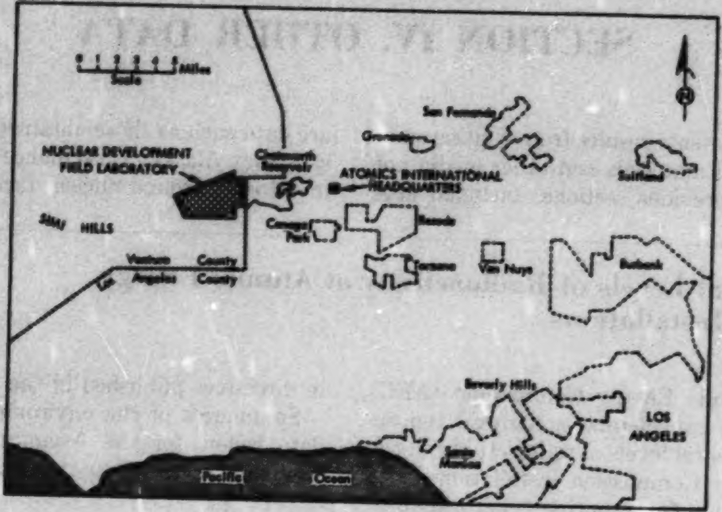

0 1 2 3 4 5 Miles
Scale
NUCLEAR DEVELOPMENT FIELD LABORATORY
Chatsworth Reservoir
ATOMICS INTERNATIONAL HEADQUARTERS
San Fernando
Granada
Sunland
SIMI HILLS
Canoga Park
Reseda
Ventura County
Los Angeles County
Tarzana
Van Nuys
Burbank
Beverly Hills
LOS ANGELES
Santa Monica
Pacific Ocean

Figure 1. Atomics International facilities and vicinity

with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on HV-70 filter paper which is automatically changed at the end of each sampling period. The filter is removed from the sampler and counted after the radioactivity is allowed to decay for at least 72 hours. The volume of a typical daily environmental air sample is approximately 20 cubic meters. The average concentration of long-lived beta-gamma radioactivity on airborne particulates is presented in table 1 for January–June 1970.

Table 1. Beta-gamma radioactivity of airborne particulates, Atomics International, January–June 1970

Location	Number of samples	Average concentration[a] (pCi/m³)
Headquarters	324	0.46
NDFL	1,212	.46

[a] Minimum detectable level—0.04 pCi/m³.

When abnormally high airborne radioactivities are observed, the radioactivity decay data are plotted to determine the presence of long-lived isotopes other than naturally occurring radon, thoron, and daughters. If fallout is suspected, the decay characteristics are observed. If the radioactivity decays as a function of $t^{-1.2}$, the data curve is extrapolated in order to determine the date of origin. These data are compared with the dates of publicized nuclear detonations to determine if the abnormal airborne radioactivity was caused by such detonations.

A graph of averaged long-lived airborne radioactivity concentrations detected at the Headquarters and NDFL facilities during the first half of 1970 is presented in figure 2. The graph shows a generally increasing trend through the spring months with a prominent peak noted in May.

Water monitoring

Process water used at the NDFL is obtained from Ventura County Water District No. 10 and distributed onsite by the same piping system previously used when process water was supplied by onsite wells. Pressure is provided by elevated storage tanks, one 50,000-gallon and one 500,000-gallon tank onsite. While clinically potable, the water is not used for drinking. Bottled potable water is delivered by a vendor and is not analyzed. Water from the pipe system is sampled monthly at two locations. The average process water radioactivity concentration is presented in table 2.

Soil, vegetation, and water are sampled monthly at Chatsworth Reservoir which is operated by the Los Angeles City Department of Water and Power. Normally, one water sample is obtained from the lake surface and a second sample is obtained from

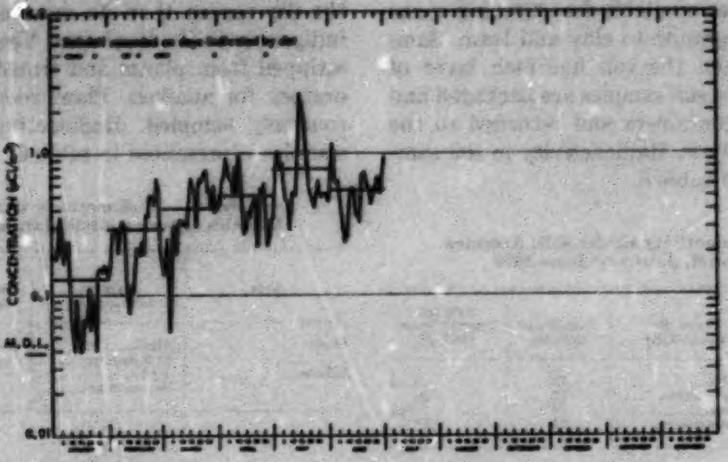


Figure 2. Long-lived airborne radioactivity at Atomics International, 1970

Table 2. Process water radioactivity, NDFL site January–June 1970

Type of radioactivity	Number of samples	Average concentration (pCi/liter)
Alpha	12	0.05
Beta-gamma	12	5.6

the reservoir water supply inlet located on the north side of the lake. The lake was drained in July 1969 for construction, thereby precluding sampling for most of the last half of 1969, and the current reporting period. The average radioactivity for both surface and supply water samples is presented in table 3.

Table 3. Chatsworth Reservoir water radioactivity, Atomics International, January–June 1970

Sample[a]	Type of radioactivity	Number of samples	Average concentration (pCi/liter)
Supply inlet	Alpha	6	0.18
	Beta-gamma	6	5.9

[a] No samples were collected from the lake surface for this period.

Surface discharged waters from NDFL facilities drain into holding reservoirs on adjacent property. When full, the main reservoir is drained into Bell Creek, a tributary of the Los Angeles River in the San Fernando Valley, Los Angeles County. Pursuant to the requirements of Los Angeles Regional Water Quality Control Board Resolution 66-49 of September 21, 1966, an environmental sampling station has been established in Bell Creek Canyon, approximately 2.5 miles downstream from the south NDFL boundary. Samples, obtained and analyzed monthly, include stream bed mud, vegetation, and water. Average radioactivity concentrations in the main holding reservoir and Bell Creek samples are presented in table 4.

Table 4. Radioactivity in the Rocketdyne reservoir and Bell Creek,[a] January–June 1970

Sample description (units)	Number of samples	Alpha radioactivity	Beta radioactivity
Reservoir station 6, water[a] (pCi/liter)	6	0.05	6.7
Reservoir station 12, water[a] (pCi/liter)	6	.07	7.6
Bell Creek, mud (pCi/g)	6	.34	25
Bell Creek, vegetation (pCi/g ash)	6	.29	171
Bell Creek, water (pCi/liter)	6	.019	4.0

[a] Location not shown on figure 1.

Soil and vegetation monitoring

Soil and vegetation are regularly sampled at 25 locations. Eleven sampling stations are located within the boundaries of Atomics International's sites and are referred to as "onsite" stations. The remaining 14 stations, located within a 10-mile radius of sites, are referred to as "offsite" stations.

Surface soil types available for sampling range from decomposed granite to clay and loam. Samples are taken from the top half-inch layer of ground surface. The soil samples are packaged and sealed in plastic containers and returned to the laboratory for analysis. Radioactivity in soil samples is presented in table 5.

Table 5. Radioactivity in the soil, Atomics International, January–June 1970

Area	Type of radioactivity	Number of samples	Average concentration (pCi/g)
Onsite	Alpha	72	0.39
	Beta-gamma	72	28
Offsite	Alpha	24	.41
	Beta-gamma	24	26

Vegetation samples obtained in the field are of the same plant type wherever possible, generally, sunflower or wild tobacco plant leaves. These types maintain a more active growth rate during the dry season than do most natural vegetation indigenous to the local area. Vegetation leaves are stripped from plants and transferred to the laboratory for analysis. Plant root systems are not routinely sampled. Radioactivity in vegetation samples is presented in table 6.

Table 6. Radioactivity in vegetation, Atomics International, January–June 1970

Area	Type of radioactivity	Number of samples	Average concentration (pCi/g ash)
Onsite	Alpha	72	0.41
	Beta-gamma	72	169
Offsite	Alpha	24	.30
	Beta-gamma	24	154

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1969	March 1970
July–December 1969	August 1970

---

2. Neutron Devices Department [3]
January–June 1970

General Electric Company
St. Petersburg, Fla.

The Neutron Devices Department (figure 3) is an electronic component production facility. The plant maintains an environmental monitoring program to measure the levels of radioactive environmental contamination associated with plant effluents. These measurements serve as an index of the effectiveness of the plant's contamination control measures. Sewer effluent, surface water, milk and air within 6 miles of the plant are monitored for radioactivity. The radioactivity concentrations, weighted by atmospheric and stream dilution factors, are compared against the AEC standards for continuous nonoccupational exposure as presented in AEC Manual chapter 0524.

Sewer effluent monitoring

A combined sewer effluent sample is obtained daily near the perimeter of the plant's property. During the sampling period, 20 of 137 samples analyzed showed detectable concentrations of tritium (detectable level 90 nCi/liter). The maximum concentrations (1.10 μCi/liter, detected on January 20, 1970) represented 37 percent of the continuous nonoccupational exposure guide. Calculations based on radioactivity releases from the process waste system and the plant's water discharges indicate that the average tritium concentration in the combined sewer effluent for the first half of 1970 was less than 7.9 percent of the AEC standard for continuous nonoccupational exposure.

Surface water sampling

Surface water samples are collected at monthly intervals at selected locations within 6 miles of the plant. The sampling areas are determined by interrelating the concentrations of radioactivity in exhaust stack effluent with meteorological data. There were no indications of tritium (detectable

---

[3] Summarized from "Environmental Monitoring, January 1 through June 30, 1970," General Electric Company, Neutron Devices Department, St. Petersburg, Fla.

118

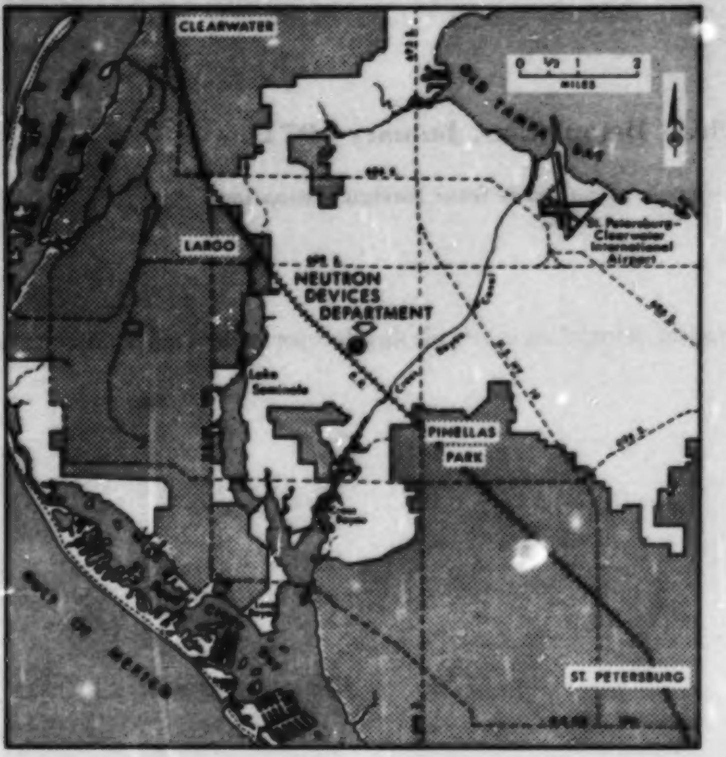

CLEARWATER
OLD TAMPA BAY
0 1/2 1 2
MILES
LARGO
NEUTRON DEVICES DEPARTMENT
St. Petersburg-Clearwater International Airport
Lake Seminole
PINELLAS PARK
GULF OF MEXICO
ST. PETERSBURG

Figure 3. Location of the Neutron Devices Department

level-50 nCi/liter) in the 137 surface water samples analyzed during the sampling period.

Milk sampling results

Analyses of 14 milk samples, collected from one local dairy farm by the Pinellas County Health Department, revealed no detectable concentrations (detectable level-90 nCi/liter) of tritium.

Air sampling results

One tritium gas and three tritium oxide in air samples obtained at the perimeter of the plant property, downwind from the exhaust stack revealed no detectable amounts of tritium gas (detectable level-20 μCi/m^3) or tritium oxide (detectable level-5 nCi/m^3).

Summary

Offsite radioactivity concentrations encountered by the general population are substantially lower than the AEC standards for continuous nonoccupational exposure.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1969	April 1970
July–December 1969	August 1970

Reported Nuclear Detonations, January 1971

Includes seismic signals presumably from foreign detonations

There were no nuclear detonations or seismic signals reported by the U.S. Atomic Energy Commission for January 1971.

Information in this section is based on data received during the month, and is subject to change as additional information may become available. Persons requiring information for purposes of compiling announced nuclear detonation statistics are advised to contact the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

THE UPTAKE OF CERIUM-144, PROMETHIUM-147, AND PLUTONIUM-238 BY OAT PLANTS FROM SOILS.

S. L. Cummings and L. Bankert. Radiological Health Data and Reports, Vol. 12, February 1971, pp. 83–85.

The uptakes of cerium-144, promethium-147, and plutonium-238 by oat plants were determined for nine soils, and promethium-147 and plutonium-238 uptakes compared with cerium-144 uptake. The percentage uptake values for all three radionuclides were very low, ranging from 10^{-6} to 10^{-3} percent. Nitrogen and potassium fertilizers increased the uptake of promethium-147 by oat plants from an Amite soil. Because the amount of cerium-144, promethium-147, and plutonium-238 taken up by plants from soils is very small, the health hazards to man by the soil-plant-man pathway from these radionuclides will probably be negligible at the levels used in this study.

KEYWORDS: cerium-144, fertilizers, oat plants, plutonium-238, promethium-147, soils, uptake.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1971—[illegible]

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 12, Number 3, March 1971

***Radiological Health Data and Reports*, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.**

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Environmental Protection Agency
Atomic Energy Commission

CONTENTS

Page

REPORTS

Summary of Environmental Monitoring at Ames Laboratory, 1962-1969 119
J. J. Copp

Results of Radiation Safety Surveys of X-ray Facilities within the Bureau of Prisons and Federal Health Programs Service 129
L. A. Miller and *L. C. Seabron*

Color Television Survey in Pennsylvania 137
R. A. Lane

TECHNICAL NOTES

Strontium-90 and Cesium-137 Levels in the Diet of Children on a School Lunch Program 139
P. S. Weng and C. N. Hsu

DATA

SECTION I. MILK AND FOOD 141

Milk Surveillance, November 1970 141

Food and Diet Surveillance 150

SECTION II. WATER 151

CONTENTS—continued

Page

SECTION III. AIR AND DEPOSITION 152

Radioactivity in Airborne Particulates and Precipitation 152

1. Radiation Alert Network, November 1970, *EPA* 153
2. Canadian Air and Precipitation Monitoring Program, November 1970 156
3. Pan American Air Sampling Program, November 1970, *PAHO* and *PHS* 157
4. Plutonium in Airborne Particulates, January-June 1970, *EPA* 157

SECTION IV. OTHER DATA 159

Environmental Levels of Radioactivity at Atomic Energy Commission Installations 159

1. Feed Materials Production Center, January-June 1970 159
2. Paducah Plant, January-June 1970 162

Nuclear Power Plants in the United States, December 1970 165

Reported Nuclear Detonations, February 1971 168

Errata 169

Synopses iii

Guide for Authors .... Inside back cover

RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

Dr. Joseph A. Lieberman
Acting Commissioner
Radiation Office

BOARD OF EDITORIAL ADVISORS

Dr. Harold O. Wyckoff
Department of Defense

Dr. Milton W. Lammering
Environmental Protection Agency

Dr. Maurice H. Frere
Department of Agriculture

Dr. Carl O. Muehlhause
Department of Commerce

Robert E. Simpson
Department of Health, Education, and Welfare

Dr. Martin B. Biles
Atomic Energy Commission

STAFF

Editor	Samuel Wieder
Managing Editor	Kurt L. Feldmann
Editorial Assistants	Jacqueline J. Copp Mary Nesdore
Illustrator	Marylee Hill

Address correspondence to the Editor, *Radiological Health Data and Reports* Radiation Office, 5600 Fishers Lane, Rockville, Md. 20852.

For subscriptions to *Radiological Health Data and Reports*, please use the order form on last page of this issue.

ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

Reports

Summary of Environmental Monitoring at Ames Laboratory,[1] 1962-1969

J. J. Copp[2]

The Ames Laboratory Research Reactor facility (ALRR), operated for the U.S. Atomic Energy Commission by the Iowa State University of Science and Technology, reached full power in July 1965. The preoperational and present environmental monitoring program consists of gross alpha and gross beta radioactivity determinations in air, soil, vegetation, river water, ALRR outfall, river bottom sediment, precipitation, well water, and pond water samples.

The average beta radioactivity levels in air ranged from 3.86 pCi/m^3 in 1963 to 0.12 pCi/m^3 in 1967. The 1964 average level of beta radioactivity (1.26 pCi/m^3) was about one-third of the 1962–1963 average levels.

The beta radioactivity in soil increased from 1962 to a peak of 20 pCi/g in 1964, probably due to weapons fallout, then decreased to a plateau of 13–15 pCi/g in 1965 through 1969. The alpha radioactivity increases from 1962 to 1964 and leveled to a plateau (1964–1969) of 0.7–1.0 pCi/g.

Vegetation samples show decreasing levels of beta radioactivity to 20–30 pCi/g. The alpha radioactivity in vegetation was variable with a general decrease from 1962 to 1965, leveling to 0.1–0.2 pCi/g in 1966–1968 and showing a rise to 0.91 pCi/g in 1969.

The environmental data indicate that any radiation that may have been contributed by the Ames Laboratory Research Reactor facility could not be detected.

The research group at Ames was given the responsibility of uranium metal preparation studies required for atomic bomb development in February 1942, and the uranium metal produced by this group was accepted as having the necessary quality needed for the success of the Plutonium Program (*1*). The pilot plant produced more than 2 tons of uranium ingots and part of this metal from Iowa State College was used when the world's first atomic chain reaction reached criticality on December 2, 1942 (*1*).

The Ames Laboratory Research Reactor facility (ALRR) was established to conduct research on materials in a radiation field, produce radioactive nuclides for inorganic and analytical chemistry studies, search for the relationship between structure and properties of materials, and investigate corrosion of metal containers by liquid metals in the presence of intense neutron irradiation and many other problems in chemistry, physics, metallurgy, and engineering.[3]

Today, ALRR has the finest selection of rare earth elements and compounds in the world. The rare earths are usually found in the same ores with thorium and uranium and are formed as byproducts during the irradiation of nuclear fuel[4]. They are used commercially to improve the properties of steel, iron, copper, aluminum, and magnesium used in a variety of metal products. In addition, they are used as catalysts, paint driers, activators for fluorescent lighting, phosphors in color television tubes and reagent chemicals.[4] Research at Ames Laboratory has included methods for separating zirconium and hafnium; methods for separating niobium and tantalum, a technique for separation of uranium-233 from thorium; and liquid metal extraction methods for removal of fission products and plutonium from power reactor fuels.[3]

---

[1] Data compiled from U.S. Atomic Energy Commission, Research and Development Reports, Survey of Environmental Radioactivity by Milo D. Voss; TID–20369 (December 31, 1963); IS–1098 (December 1964); IS–1320 (December 1965); IS–1523 (January 1967); IS–1647 (August 1967); IS–1776 (January 1968); IS–2025 (January 1969); and IS–2260 (February 1970).

[2] Mrs. Copp is with the Radiation Office, Environmental Protection Agency, Rockville, Md. 20852.

[3] U.S. Atomic Energy Commission news release of May 2, 1963.

[4] U.S. Atomic Energy Commission news release of January 14, 1966.

The ALRR, operated for the U.S. Atomic Energy Commission by the Iowa State University of Science and Technology, is located at Ames, Iowa, approximately 30 miles north of Des Moines, Iowa. The ALRR was still under construction as of December 31, 1964, reached full power in July 1965 and had generated 87,654 megawatt-hours thermal as of June 30, 1969.

The preoperational monitoring program conducted from October 1962 to June 1965 consisted of gross alpha and gross beta radioactivity measurements on air, soil, vegetation, river water, river bottom sediment, precipitation, and well water samples. Table 1 gives the average levels of radioactivity in preoperational sampling media. From this table, one change is noticeable from the data over the 3-year period. The decreases in radioactivity reported in air and precipitation probably reflect the decreasing inventory of world-wide fallout. Since isotopic analysis was not performed on the sampled media, it is impossible to relate the sources for the increases in soil, bottom sediment, and well water samples.

The basic concept of radiological hazard control at Ames Laboratory encourages total containment of radioactive materials, and through rigid operational controls, minimizes effluent releases and external radiation levels.

Basic standards

The radiation protection standards observed at ALRR for exposure to radiation and radioactive materials both for the occupationally exposed population and for offsite exposure to the general population are those contained in Appendix 0524 of the AEC Manual.[5]

The standards specify that radiation or radioactive materials outside a controlled area which have resulted from operations within that controlled area shall be such that it is improbable that any individual will receive a dose of radiation greater than 0.5 rem in any year, and that the average exposure of a suitable population sample will not exceed one-third of this dose. To meet this standard, the average concentration of radioisotopes in air or water beyond a controlled area should not exceed one-tenth of the maximum permitted for occupational exposure (168 hours per week). For the purposes of such control, the concentrations of such radionuclides in air or water may be averaged over periods of time up to 1 year.

---

[5] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the same standards as the AEC Manual.

Table 1. Average levels of beta and alpha radioactivity in preoperational sampling media, ALRR, October 1962–June 1965[a]

Sampling media and concentration	Oct–Dec 1962		1963		1964		Jan–June 1965	
	Beta radioactivity	Alpha radioactivity	Beta radioactivity	Alpha radioactivity	Beta radioactivity	Alpha radioactivity	Beta radioactivity	Alpha radioactivity
Air (pCi/m^3)	3.40	0.05	3.86	0.11	1.26	0.014	0.44	0.010
Soil (pCi/g)	7.57	.26	9.45	.56	20.0	.94	(b)	(b)
Vegetation (pCi/g)	117	1.62	87.5	.96	73.3	1.27	(b)	(b)
River water (pCi/liter) (total solids)	18.1	1.01	55.0	2.09	18.3	.89	26.6	92
River bottom sediment (pCi/g)	9.88	.25	10.6	.61	11.1	.47	(c)13.9	.61
Precipitation (pCi/liter)	2,020	65.9	1,360.	39.2	366.	12.7	1,380.	5.7
Well water (pCi/liter)	4.01	.31	4.78	1.04	6.83	1.42	8.48	1.38

[a] The ALRR facility reached full power in July 1965. Preoperational sampling was carried on until that date.
[b] Soil and vegetation samples were collected in August 1965 when plant was operational.
[c] River bottom sample collected April 30, 1965.

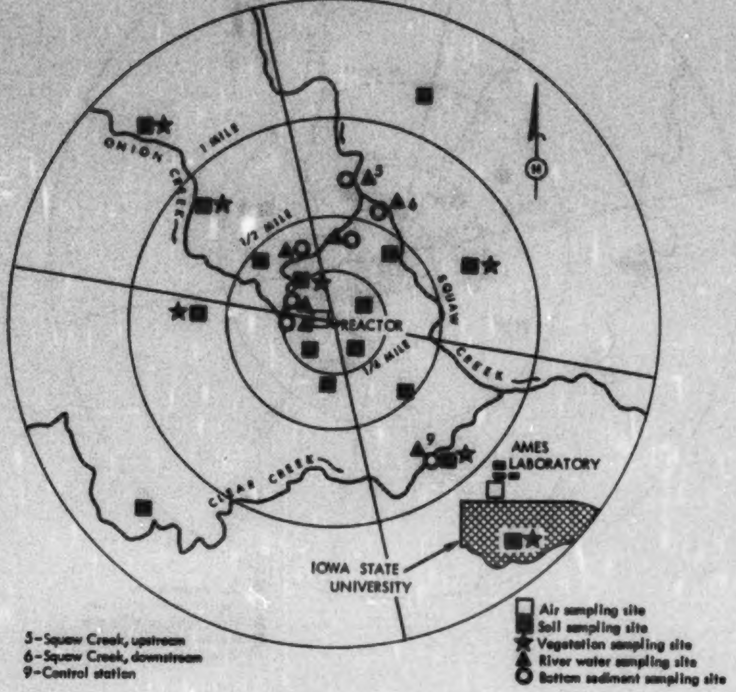

1 MILE
1/2 MILE
1/4 MILE
ONION CREEK
SQUAW CREEK
CLEAR CREEK
REACTOR
5
6
9
AMES LABORATORY
IOWA STATE UNIVERSITY
Air sampling site
Soil sampling site
Vegetation sampling site
River water sampling site
Bottom sediment sampling site
5–Squaw Creek, upstream
6–Squaw Creek, downstream
9–Control station

Figure 1. Environmental sampling sites within the ALRR environs

Air monitoring

Daily air samples are taken at a location on top of the Ames Laboratory Research building. Samples are collected on Whatman #41 filter paper with a Gast pump at the flow rate of 3.75 cfm. The filter samples are counted for gross alpha and gross beta radioactivity 7 days after collection to allow the decay of naturally occurring radon and thoron daughters.

Average levels of gross beta and gross alpha radioactivity in surface air at ALRR for 1962 to 1969 are given in table 2. The average beta radioactivity levels ranged from 3.86 pCi/m^3 in 1963 to 0.12 pCi/m^3 in 1967. The average level of beta radioactivity in 1964 was 1.26 pCi/m^3, about one-third of the 1962–1963 average levels. It can therefore be assumed that the influence of the nuclear weapons tests begun in September 1961 caused the high levels in 1962 (*2*). Data for 1963 showed an anticipated spring increase resulting from the mixing of stratospheric debris into the troposphere even though the atmospheric weapons test moratorium began in December 1962 (*2*). Since the ALRR facility was still under

Table 2. Yearly average levels of radioactivity in surface air, Ames Laboratory, 1962–1969

Year	Number of samples	Concentration (pCi/m^3)	
		Gross beta radioactivity	Gross alpha radioactivity
1962[a]	133	3.40	0.05
1963	263	3.86	.11
1964	310	1.26	.014
1965[b]	327	.30	.007
1966	274	.15	< .003
1967	275	.12	.004
1968	245	.20	.005
1969	187	.24	.004

[a] Air sampling program was started June 22, 1962.
[b] Reactor reached full power July 1965.

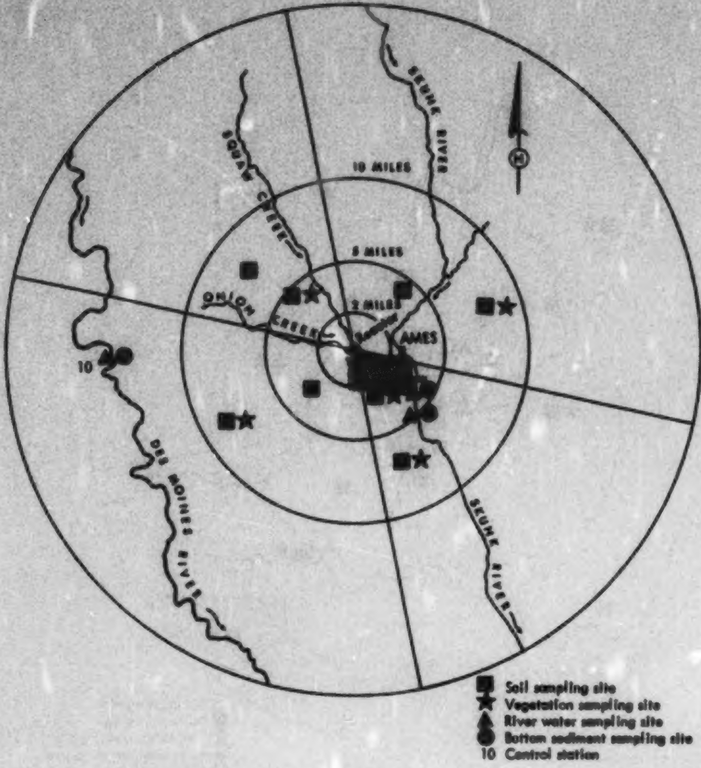

SKUNK RIVER
SQUAW CREEK
10 MILES
5 MILES
2 MILES
ONION CREEK
AMES
10
DES MOINES RIVER
SKUNK RIVER
Soil sampling site
Vegetation sampling site
River water sampling site
Bottom sediment sampling site
10 Control station

Figure 2. Offsite surveillance, ALRR

construction and did not reach full power until July 12, 1965, it is appropriate to conclude that radioactivity levels in surface air (1962–1965) resulted from atmospheric fallout and naturally occurring radioactivity.

Soil and vegetation

Soil and vegetation samples are collected once each year. Circles surrounding the ALRR site were divided into 4 sectors on the basis of wind direction frequencies. Annuli were chosen on the basis of simplicity for defining sampling areas with one sample being taken from each sector (figures 1 and 2). Reference samples are collected at Fort Dodge, Iowa.

One quart soil samples were collected from the top 2-inch layer of soil. The samples are dried thoroughly in a 100°C drying oven, mixed thoroughly, with large stones and roots being removed. A 3- to 4-gram counting sample was taken from the dried soil, placed on a 3-inch aluminum planchet and counted directly in the Sharp low-beta counting system for gross alpha and gross beta radioactivity. The accuracy of the data varies with the sample size and counting time, but is generally at least ±10 percent.

Table 3 shows the average levels of radioactivity

Table 3. Yearly average levels of radioactivity in soil samples, Ames Laboratory, 1962–1969

Year	Concentration (pCi/g dry weight)	
	Gross beta radioactivity	Gross alpha radioactivity
1962	7.57	0.26
1963	9.45	.56
1964	20.0	.94
1965	14.5	.86
1966	15.0	.68
1967	13.8	.99
1968	13.4	.81
1969	14.0	.98

127

in the 25 yearly samples collected from 1962 through 1969. The beta radioactivity in soil increased from 1962 to 1964, peaked in 1964 and decreased to a plateau of 13 to 15 pCi/g in 1965 through 1969. The alpha radioactivity increased from 1962 to 1964 and leveled to a plateau of 0.7–1.0 pCi/g in 1964–1969.

Thirteen yearly vegetation samples are obtained from the same location as the soil samples. Date of collection is correlated to maximum growth period, which is July and August for this area. In order to minimize surface contamination, samples are not collected after precipitation of any kind. The type of vegetation is confined to grasses, and none of the root systems are included in the samples.

Radioactivity in vegetation samples is presented in table 4 and shows decreasing levels of beta radioactivity leveling to a plateau of 20 to 30 pCi/g. The alpha radioactivity in vegetation

Table 4. Average levels of radioactivity in 13 yearly vegetation samples, 1962–1969

Year	Concentration (pCi/g dry weight)	
	Gross beta radioactivity	Gross alpha radioactivity
1962	117	1.62
1963	87.5	.98
1964	73.3	1.27
1965	32.5	.38
1966	34.0	.13
1967	20.6	.21
1968	24.9	.13
1969	30.5	.91

Table 5. Comparison of gross beta radioactivity in vegetation and soil samples collected at the same sites, Ames Laboratory environs, 1962–1969 (concentration, pCi/g dry weight)

Soil and vegetation sampling locations[a]	1962		1963		1964		1965	
	Vegetation	Soil	Vegetation	Soil	Vegetation	Soil	Vegetation	Soil
NW 1	69.4	9.0	10.5	9.9	101.	25.0	35.4	17.1
SE 3	10.8	9.4	86.0	7.8	68.0	29.5	43.0	13.1
SW 3	181.	7.0	186.	10.3	63.0	20.3	30.9	13.5
NW 3	125.	8.3	160.	8.8	67.0	19.1	29.4	12.4
NE 3	105.	9.0	126.	8.6	51.0	21.3	41.5	13.5
SE 4	42.2	8.2	84.0	9.0	87.0	21.0	43.0	15.7
NW 4	125.	5.2	58.0	9.0	65.0	21.3	29.6	13.3
SE 5	132.	6.0	62.0	8.5	55.0	19.9	31.2	15.7
NW 5	158.	6.3	87.0	8.5	80.7	18.3	26.2	15.9
SE 6	145.	7.2	62.0	8.1	124.	18.8	29.6	14.0
SW 6	132.	7.2	61.0	9.7	67.5	14.7	26.0	15.9
NE 6	132.	6.1	55.0	8.3	71.1	22.4	27.6	16.4
Control station, Ft. Dodge	167.	6.7	100.	14.0	52.1	21.2	29.0	16.6
Average	117.	7.4	87.5	9.3	73.3	21.0	32.5	14.8
Maximum	181.	9.4	186.	14.0	124.	29.5	43.0	17.1
Minimum	10.8	5.2	10.5	7.8	51.0	14.9	26.0	12.4

Soil and vegetation sampling locations[a]	1966		1967		1968		1969	
	Vegetation	Soil	Vegetation	Soil	Vegetation	Soil	Vegetation	Soil
NW 1	33.0	13.3	20.5	14.4	35.8	13.3	33.1	13.3
SE 3	33.0	15.2	26.2	14.0	24.3	12.7	32.5	14.4
SW 3	31.0	14.0	24.2	13.1	29.6	12.3	24.6	13.6
NW 3	24.0	11.0	22.0	15.5	34.5	10.5	36.9	11.7
NE 3	27.0	15.8	19.6	12.3	9.9	12.7	45.2	12.2
SE 4	33.0	35.3	21.7	14.0	26.1	13.9	46.2	15.8
NW 4	20.0	13.0	19.3	12.5	20.3	13.0	20.8	14.1
SE 5	90.0	12.7	18.9	11.5	26.8	15.5	27.8	13.6
NW 5	28.0	14.6	17.7	13.2	17.8	13.3	16.3	12.9
SE 6	23.0	11.1	17.0	11.0	22.3	11.8	28.7	12.8
SW 6	21.0	16.0	16.6	14.4	33.1	12.9	24.4	14.9
NE 6	33.0	16.1	23.8	13.4	24.6	11.6	26.9	13.3
Control station, Ft. Dodge	46.0	18.5	19.5	16.2	18.4	13.4	32.8	15.2
Average	34.0	15.9	20.6	13.5	24.9	12.8	30.5	13.7
Maximum	90.0	35.3	26.2	16.2	35.8	15.5	46.2	15.8
Minimum	20.0	11.0	16.6	11.0	9.90	10.5	16.3	11.7

[a] Sampling locations shown in figures 1 and 2.

Table 6. Comparison of gross alpha radioactivity in vegetation and soil samples collected at the same sites, Ames Laboratory environs, 1962-1969 (concentration, pCi/g dry weight)

Soil and vegetation sampling locations[a]	1962		1963		1964		1965	
	Vegetation	Soil	Vegetation	Soil	Vegetation	Soil	Vegetation	Soil
NW 1	0.45	0.25	0.63	0.33	1.31	0.53	0.61	0.78
SE 3	1.26	.33	.48	.33	1.61	.76	.64	.88
SW 3	1.89	.13	1.20	.46	1.52	1.08	.46	.90
NW 3	2.97	.16	4.10	.47	1.06	1.08	.20	.82
NE 3	2.13	.20	1.13	.62	.84	.67	.42	.64
SE 4	.74	NA	.21	.57	1.56	1.15	.35	1.15
NW 4	.44	.24	.56	.47	1.26	.88	.20	.69
SE 5	.11	.60	.15	.77	.35	.81	.16	1.15
NW 5	.16	.19	.85	.53	1.48	1.14	.26	1.20
SE 6	1.98	.18	NA	.56	3.24	.96	1.06	.56
SW 6	1.53	.21	.35	1.08	.72	.92	.07	.80
NE 6	1.46	.31	2.20	.83	.77	1.31	.25	.77
Control station, Ft. Dodge	4.00	.22	.62	.36	.86	.97	.20	.93
Average	1.62	0.23	0.96	0.56	1.77	0.94	0.38	0.87
Maximum	4.00	0.60	4.10	1.08	3.24	1.31	1.06	1.20
Minimum	0.11	0.13	0.15	0.33	0.35	0.53	0.07	0.56

Soil and vegetation sampling locations[a]	1966		1967		1968		1969	
	Vegetation	Soil	Vegetation	Soil	Vegetation	Soil	Vegetation	Soil
NW 1	ND	0.39	ND	0.83	0.22	0.06	1.63	0.91
SE 3	ND	.55	ND	.81	ND	1.01	.88	1.00
SW 3	ND	1.08	.29	.38	.24	.14	.90	1.09
NW 3	ND	.23	ND	.41	ND	.42	.67	.56
NE 3	ND	.72	ND	.71	.86	1.02	.45	1.00
SE 4	.27	1.16	.71	1.22	ND	.87	1.68	1.23
NW 4	ND	.54	.26	1.01	ND	.82	.64	1.61
SE 5	ND	.88	.48	1.16	ND	.66	.89	.92
NW 5	.77	.75	.23	1.08	ND	1.19	.67	.91
SE 6	.30	.72	ND	.76	ND	.65	1.12	.65
SW 6	.41	1.02	.21	1.27	ND	.68	.68	1.16
NE 6	ND	.78	ND	.83	ND	.93	.68	.86
Control station, Ft. Dodge	ND	1.20	.61	1.51	.34	.79	.90	1.35
Average	[b]0.44	0.77	[b]0.40	0.92	[b]0.42	0.71	0.91	1.[illegible]
Maximum	0.77	1.20	0.71	1.27	0.86	1.19	1.68	[illegible].61
Minimum	ND	0.23	ND	0.38	ND	0.06	0.45	0.65

[a] Sampling locations shown in figures 1 and 2.
[b] Average excludes nondetectable samples.
ND, nondetectable. Detectable level varies with sample size and counting time.
NA, no analysis.

samples was variable. There is a general decrease from 1962 to 1965 to 0.1–0.2 pCi/g in 1966–1968, with a rise in 1969.

Table 5 presents the data for gross beta radioactivity of soil samples (same sampling sites as vegetation) and vegetation samples for 1962 through 1969, and table 6 shows similar data for gross alpha radioactivity.

River water samples

River water samples are collected weekly and analyzed for gross alpha and gross beta radioactivity. One-liter samples are filtered and counted separately as suspended and dissolved solids. Generally, no attempt is made to report the specific radionuclides present.

Table 7. Averages of beta radioactivity at Ames Laboratory river water sampling sites, 1963–1969 (Concentration, pCi/liter)

Site number and sampling location[a]	1963		1964		1965	
	Dissolved	Suspended	Dissolved	Suspended	Dissolved	Suspended
1–Drainage ditch, upstream	19.0	9.28	27.0	8.46	13.4	16.6
2–Drainage ditch, downstream	23.8	7.94	10.1	1.79	6.50	.76
3–Onion Creek, upstream	26.9	19.8	16.1	1.82	18.0	1.88
4–Onion Creek, downstream	18.2	8.53	10.4	1.03	6.51	.80
5–Squaw Creek, upstream	21.3	19.1	17.3	8.01	15.9	1.67
6–Squaw Creek, downstream	98.3	17.6	14.4	2.46	17.9	1.01
7–Skunk River, upstream	26.0	16.0	20.3	4.78	27.3	1.28
8–Skunk River, downstream	44.1	21.8	(c)			
9–Clear Creek	52.6	34.4	15.3	2.13	19.0	1.00
10–Des Moines River	22.1	19.0	13.7	4.58	13.1	2.62
11–Skunk River sewage outfall	23.0	25.3	18.4	2.71	12.8	.93

Site number and sampling location[a]	1966		1967		1968		1969	
	Dissolved	Suspended	Dissolved	Suspended	Dissolved	Suspended	Dissolved	Suspended
1–Drainage ditch, upstream	9.43	3.07	3.69	0.39	6.50	3.40	5.13	0.77
2–Drainage ditch, downstream	11.3	.97	9.94	1.28	[b]10.0	[b]1.16	10.9	1.32
3–Onion Creek, upstream	9.34	16.9	10.5	1.37	7.07	2.07	5.35	4.22
4–Onion Creek, downstream	4.96	.92	6.62	.57	5.61	.50	4.08	1.74
5–Squaw Creek, upstream	10.9	2.24	13.1	1.08	7.34	2.20	6.78	4.18
6–Squaw Creek, downstream	13.0	3.57	7.06	1.00	7.95	1.94	6.78	4.42
7–Skunk River, upstream	11.4	1.69	9.80	.96	8.06	2.24	6.91	4.54
9–Clear Creek	11.9	20.7	8.12	.74	8.07	2.44	5.36	2.13
10–Des Moines River	9.44	4.66	9.29	2.25	8.09	3.21	7.60	4.48
11–Skunk River sewage outfall	15.6	.74	15.8	.96	14.5	1.07	12.2	1.15

[a] Sampling sites shown in figures 1 and 2.

[b] On April 11 and 12, 1968, sodium-24 used for tracer work in the secondary cooling system was detected in the outfall water. The levels were 450 pCi/liter and 2.3 nCi/liter. The AEC standard for sodium-24 is 200 nCi/liter. On September 18–19, 1968, lutetium-177 discharged from the Reactor building was detected in the outfall water at levels of 1.17 nCi/liter and 737 pCi/liter. The AEC standard for lutetium-177 is 100 nCi/liter. As the specific isotope in the two cases was identified and the rest of the data is not otherwise specified, these four dates were not included in the averages.

[c] Site discontinued (same as Skunk River sewage outfall).

Currently, samples are obtained from each river or creek (figures 1 and 2) in the flow route of the Ames Laboratory Research Reactor drainage system. In addition, two control samples are obtained from streams outside the ALRR flow route, Clear Creek and the Des Moines River. Samples are obtained at each site until the creeks go dry in late summer or until the rivers are frozen solid in winter. If water is flowing under ice, a sample is obtained by chopping through the ice.

The suspended solids portion of the sample is prepared by igniting the filter paper directly on a planchet. The dissolved solids portion is prepared by evaporating the filtrate to near dryness and transferring the residue to a planchet. The planchets are then placed directly in the Sharp low-level system for counting.

Table 7 gives the yearly averages for gross beta radioactivity in suspended and dissolved solids in river water samples for each sampling site from 1963 to 1969. The 1962 data are not presented as they included only the last 3 months. The concentration of gross radioactivity in surface waters is extremely variable because large quantities of suspended solids lead to proportionately large values for gross radioactivity expressed only in picocuries per liter (pCi/liter). These complications have been recognized and discussed (*4*, *5*). Figure 3 provides a comparison of yearly averages of gross beta radioactivity in stations 5 and 6 (Squaw Creek, up and downstream) and the two control stations 9 and 10 (Clear Creek and the Des Moines River).

In the water sampling program at Ames Laboratory, gross radioactivity has been expressed in pCi/liter of water, however, the presentation of radioactivity in suspended and dissolved solids in picocuries per gram (pCi/g) often allows a better understanding of the movement of radiological contamination in the absence of flow data. Julian (*6*) demonstrated the usefulness of solids quality[a] in reducing the uncertainties that sometimes arise when water quality has been considered without interpretation. During periods of heavy runoff, water quality can vary enormously, and radioactive contamination is difficult to determine. In such instances, total solids content (pCi/g) of water samples can assist in the proper interpretation of the data.

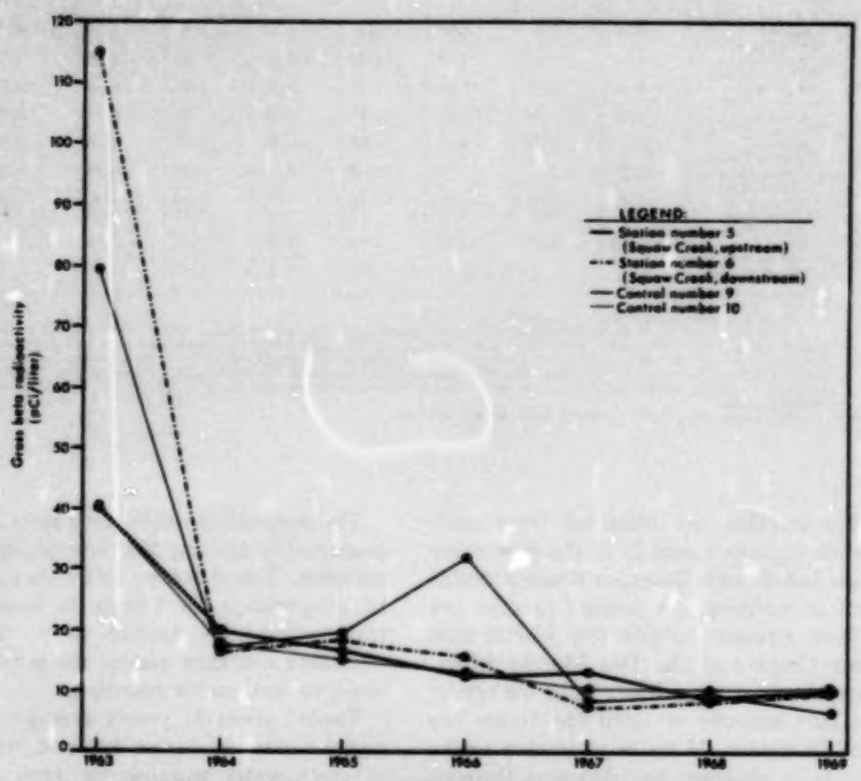


Figure 3. Comparison of yearly averages of gross beta radioactivity at four water sampling locations, ALRR, 1963–1969

---

[a] Water quality is customarily expressed in the form of weight per unit volume as g/liter. A water sample from a stream will contain solid material in suspension and this suspended material is considered a part of the water of the stream for defining the water quality. Gross radioactivity in pCi/liter is considered as water quality and solids quality as pCi/g.

River bottom sediment

Bottom sediment samples are obtained at or near the river water sampling sites on a quarterly basis and analyzed for gross alpha and gross beta radioactivity. A 1-quart sample is obtained from the top 2 or 3 inches of bottom sediment in a semiquiescent area. The sample is mixed and a counting aliquot of 3 to 4 grams is dried thoroughly in an oven and then counted directly in a Sharp low level counting system. Table 8 gives the yearly average, maximum, and minimum of gross alpha and gross beta radioactivity in river bottom sediment from 1962–1969.

Table 8. Gross alpha and gross beta radioactivity in river bottom sediment, 1962–1969

Year	Beta radioactivity[a] (pCi/g dry weight)			Alpha radioactivity[b] (pCi/g dry weight)		
	Average	Maximum	Minimum	Average	Maximum	Minimum
1962	9.88	22.7	0.60	0.25	0.94	0.09
1963	10.6	51.0	3.90	.61	8.0	.01
1964	11.1	54.0	4.50	.47	3.1	.10
1965	14.6	34.0	7.00	.89	6.7	.08
1966	13.8	31.7	5.50	.85	2.7	.06
1967	11.7	21.0	4.90	.76	2.7	.09
1968	9.84	18.4	4.10	.46	1.3	.04
1969	9.28	16.7	4.96	.49	1.5	.05

Well water

Well water samples have been collected on a monthly basis since 1962 from Ames city wells, Iowa State University (ISU) campus wells, including the ISU synchrotron well, and a privately-owned farm well located 2 miles north of the ALRR. Samples of 1 liter are filtered and counted in the same manner as the river water samples. Table 9 gives the gross alpha and gross beta radioactivity in well water samples for 1962 to 1969.

Table 9. Gross alpha and gross beta radioactivity in total solids in well water samples, Ames Laboratory 1962–1969

Year	Beta radioactivity (pCi/liter)			Alpha radioactivity (pCi/liter)		
	Average	Maximum	Minimum	Average	Maximum	Minimum
1962	4.01	6.78	2.75	0.31	0.90	0.17
1963	4.78	16.4	1.18	1.[illegible]4	5.69	.10
1964	6.83	12.9	2.60	1.42	20.9	.046
1965	6.80	22.8	2.04	1.08	5.20	.12
1966	6.93	13.0	2.30	1.14	4.00	.12
1967	7.20	15.1	2.70	1.07	4.10	.18
1968	7.35	16.2	2.17	.98	1.84	.18
1969	5.81	13.1	2.20	1.09	3.46	.18

Pond water

Pond water samples have been collected monthly since 1966 from three sites: the George Todd site, 3 miles northeast of ALRR; the Izaak Walton League site, 3 miles east of the ALRR; and the Kelley site, 5 miles south of the ALRR. The sample size is 1 liter with the concentration reported in pCi/liter. The samples are filtered and prepared for counting in the same manner as the river water samples.

The averages for beta radioactivity in total solids in pCi/liter were 16.3 for 1966; 15.2 for 1967; 14.9 for 1968; and 13.7 for 1969. Alpha radioactivity levels were 0.86 pCi/liter for 1966; 1.07 for 1967; 0.83 for 1968; and 0.84 for 1969.

Precipitation

Precipitation samples are collected on an "as it happens" basis and analyzed for gross alpha and gross beta radioactivity. Samples are collected at one site, the weather observation tower near the research reactor. The samples are filtered and prepared in the same manner as the river water samples. In November 1969, it was decided that precipitation samples would no longer be filtered to help simplify and economize the program.

Table 10 gives the number of samples and the yearly averages of gross beta and gross alpha radioactivity in precipitation from 1962 to 1969. Although the data from one onsite sampling station are insufficient to assess total human radiation exposure from fallout, they can be used for determining when to modify monitoring in other phases of the environment. The average precipitation levels reported in table 10 are similar to the data presented for the Iowa area by the

Table 10. Yearly averages of gross alpha and gross beta radioactivity in precipitation, ALRR, 1962–1969

Year	Number of samples	Concentration (pCi/liter)	
		Gross beta radioactivity	Gross alpha radioactivity
1962	5	2,020	65.9
1963	62	1,360	39.2
196[illegible]	57	366	12.7
1965	57	715	3.95
1966	38	217	9.21
1967	52	75.5	3.54
1968	60	81.7	4.14
1969	82	138	9.15

Radiation Surveillance Network (changed to Radiation Alert Network in November 1967) as presented in Radiological Health Data and Reports(7).

Conclusion

The environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. Surveillance of the environmental radioactivity around Ames Laboratory from 1962 to 1969 indicates that any radioactivity contributed by the Ames Laboratory Research Reactor facility to the environment could not be detected.

Acknowledgment

Appreciation is expressed to Milo D. Voss, head, Health Physics, Ames Laboratory, USAEC, for cooperation in developing the data in this report.

REFERENCES

(*1*) HEWLETT, R. A. and O. E. ANDERSON, JR. The New World, 1939/1946. Vol. 1, A History of the U.S. Atomic Energy Commission (1962) pp. 293–294.

(*2*) FEDERAL RADIATION COUNCIL. Estimates and evaluation of fallout in the United States from nuclear weapons testing conducted through 1962, FRC Report No. 4. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1963).

(*3*) FEDERAL RADIATION COUNCIL. Revised fallout estimates for 1964–1965 and verification of the 1963 predictions, Report No. 6. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (October 1964).

(*4*) STRAUB, C. P. Significance of radioactivity data. JAWWA 53:704 (June 1961).

(*5*) FLOYD, E. P. and L. WEAVER. Trends of strontium-90 levels in surface waters of the United States, 1959–1963. Radiol Health Data 5:390–394 (August 1964).

(*6*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1966. Radiol Health Data Rep 9:9–12 (January 1968).

(*7*) PUBLIC HEALTH SERVICE. Radiation Surveillance Network, October 1962. Radiol Health Data 4: January-December 1963; 5: January–December 1964; 6: January–December 1965; Radiol Health Data Rep 7: January–December 1966; 8: January–December 1967; 9:January–December 1968; 10:January–December 1969.

Results of Radiation Safety Surveys of X-ray Facilities within the Bureau of Prisons and Federal Health Programs Service

Lois A. Miller and *LaVert C. Seabron*[1]

This report presents the results of comprehensive surveys of x-ray facilities in 26 Bureau of Prison installations and in 11 hospitals and 20 outpatient clinics of the Public Health Service throughout the United States. Facility workloads, types of equipment, operator training, and equipment deficiencies are discussed.

During 1967, representatives of the Bureau of Radiological Health (BRH) began discussing the establishment of radiation safety programs with representatives of the Bureau of Prisons and the Federal Health Programs Service. As a result of these discussions, plans were developed for surveying and evaluating x-ray facilities at various installations of both the Bureau of Prisons and Federal Health Programs Service, and a survey program was proposed to each group.

The objectives of the proposed programs were:

1. To initiate and conduct a survey of all Bureau of Prisons and Federal Health Programs Service x-ray installations within a period of 1 year. Each survey was to include a complete radiological health and safety evaluation as it applied to the safety of patients, operating personnel, and occupants of adjacent areas.
2. To recommend modifications or changes in equipment and/or operating procedures which, when implemented, would reduce patient and occupational exposures.
3. To implement and administer a continuing program of radiation source registration.
4. To develop a system whereby all or selected facilities within the Bureau of Prisons and the Federal Health Programs Service would be resurveyed every 2 years.
5. To promote the application of radiation protection principles among personnel responsible for the operation of x-ray equipment.

The recommendations set forth in National Council on Radiation Protection and Measurements (NCRP) Report No. 33 (*1*) and National Bureau of Standards Handbook 76 (*2*) were suggested as guides for the survey and compliance purposes of the project.

By the end of 1967, the Bureau of Prisons and Federal Health Programs Service has each signed a Memorandum of Agreement with BRH accepting the proposed program and agreeing to the facility surveys. The actual surveys were initiated in 1968 and completed early in 1969.

PROCEDURE

Survey planning

The Bureau of Prisons estimated that there were 27 installations in 22 States (figure 1) with a total of 55 medical and dental x-ray machines to be surveyed. The number of installations actually surveyed was 24 and the number of x-ray machines was 60.

The Federal Health Programs Service estimated that there were 33 facilities to be surveyed with a total of 141 x-ray machines. The actual number of facilities surveyed was 31 and the number of x-ray machines was 148. Of the 31 facilities, 11 were hospitals and 20 were outpatient clinics (figure 2).

Survey method

Procedures followed by the surveyor were identical for each installation to allow for comparison of data at the conclusion of the survey program. The data were collected on the Public Health Service's "X-ray Protection Survey Report" forms. A specially-designed "Radiation Source Registration Form" was also used.

---

[1] Mrs. Miller and Mr. Seabron are with the Division of Electronic Products, Bureau of Radiological Health, U.S. Public Health Service, Rockville, Md. 20852.

The equipment used by the surveyor consisted of a Victoreen Condenser R-Meter including the charger-reader and ionization chambers in the ranges of 0–10 and 0–25 roentgens full scale, an ionization chamber rate meter, spinning top, fluorescent strips for beam size determinations, steel tape measure, and assorted filters and collimators.

At each, facility the x-ray equipment was registered on a Radiation Source Registration Form, and an equipment identification decal imprinted with a registration number was affixed to the control panel of each machine. Then the machine was surveyed for compliance with the NCRP guides, and the data were entered on the appropriate forms. An evaluation was then made of the physical plant itself, including an examination of the traffic patterns within the x-ray department, the shielding incorporated in the walls of the treatment room, and the proximity of the tube to adjacent occupied areas. A check was made of the darkroom facility to ensure that it was lighttight, that a thermometer was present, that a proper safelight was in use, and that the time-temperature method of development was actually being followed.

During the course of the survey, the operator of the equipment was questioned about the procedures and techniques employed and also about the training he had received since assuming his duties.

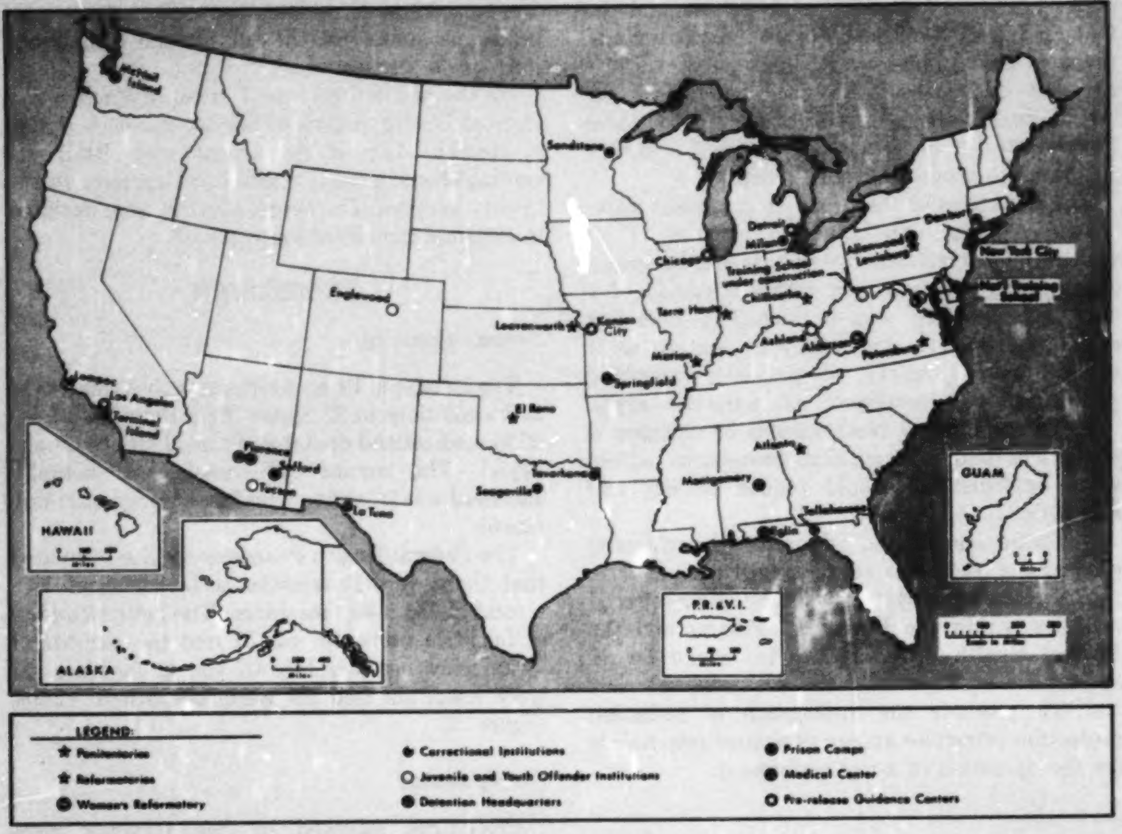

McNeil Island
Sandstone
Detroit
Milan
Chicago
Danbury
Allenwood
Lewisburg
New York City
Training School under construction
Chillicothe
NAT'L Training School
Englewood
Terre Haute
Leavenworth
Kansas City
Ashland
Alderson
Petersburg
Marion
Springfield
Lompoc
Los Angeles
Terminal Island
El Reno
Florence
Safford
Tucson
La Tuna
Texarkana
Seagoville
Atlanta
Montgomery
Tallahassee
Eglin
HAWAII
ALASKA
P.R. & V.I.
GUAM
Miles
Scale in Miles
LEGEND:
★ Penitentiaries
★ Reformatories
● Womens Reformatory
● Correctional Institutions
○ Juvenile and Youth Offender Institutions
● Detention Headquarters
● Prison Camps
● Medical Center
○ Pre-release Guidance Centers

Figure 1. Federal prison system

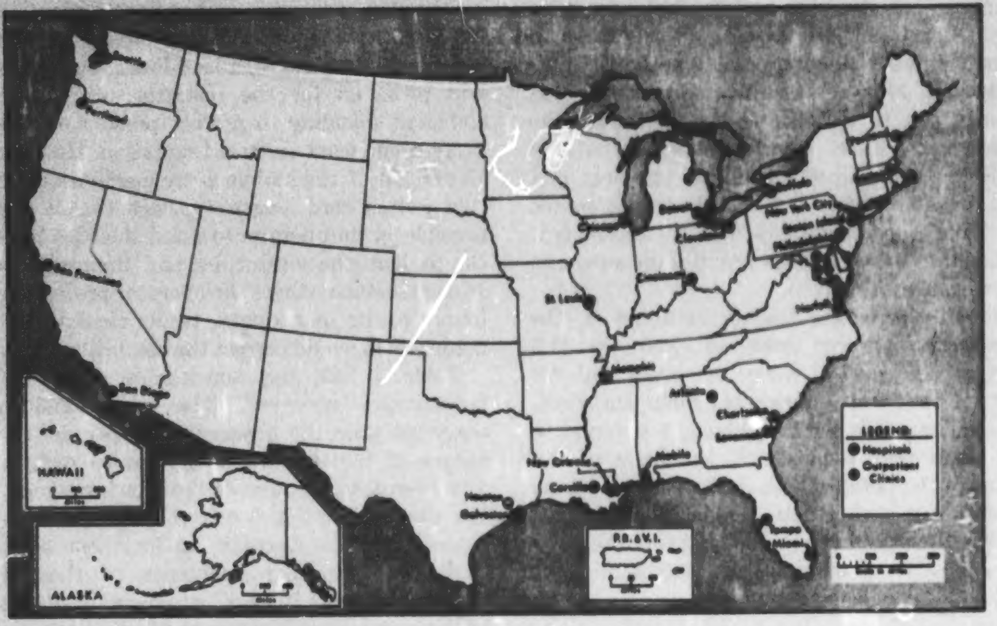

Seattle
Portland
San Francisco
San Diego
Chicago
Detroit
Cleveland
Buffalo
New York City
Staten Island
Philadelphia
St Louis
Cincinnati
Norfolk
Memphis
Atlanta
Charleston
Savannah
Mobile
New Orleans
Carville
Houston
Galveston
Tampa
Miami
HAWAII
ALASKA
P.R. & V.I.
LEGEND
Hospitals
Outpatient Clinics

Figure 2. Federal Health Programs Service facilities

Upon completion of the survey, the medical officer-in-charge or his designated representative was advised by the surveyor of any deficiencies noted during the survey. A comprehensive written report covering the survey was later submitted to the facility.

RESULTS

Bureau of Prisons facilities

Table 1 summarizes the personnel, equipment, and machine workloads of the Bureau of Prisons x-ray facilities surveyed.

Each facility surveyed consisted of one medical x-ray machine and one dental x-ray machine with the exception of the Medical Center for Federal Prisoners at Springfield, Mo. This facility, a 600-bed hospital for prisoners with mental and emotional disorders and chronic diseases, has an x-ray department equipped for most diagnostic and therapeutic procedures.

As of October 1, 1968, there were 20,030 prisoners in the 24 facilities surveyed. When one compares this number with the 130,208 x rays taken per year, it appears that each inmate receives an average of 6.5 x rays per year. In reality, the total number of x rays taken reflects the turnover

Table 1. Facility information for the Bureau of Prisons[a]

Facility information	Number	Average per facility
Personnel:		
Number of personnel occupationally exposed	155	6.4
Number of personnel monitored	193	8.0
Number of x-ray machine operators	114	4.7
Number of operators per machine	1.9	
Equipment:		
Total number of x-ray machines	60	2.5
Number of dental x-ray machines	25	1.0
Number of medical x-ray machines	35	1.5
Fixed radiographic	4	
Radiographic-fluoroscopic	21	
Mobile	8	
Photofluoroscopic	1	
Therapy	1	
Workload:		
Number of patients radiographed per year		
Medical	45,240	1,885
Dental	30,160	1,256
Number of exposures (films) per year		
Medical	78,125	3,255
Dental	52,083	2,169
Number of patients fluoroscoped per year	2,496	104
Number of therapy treatments per year	50	(b)
Radiographic workload mA-min per year		
Medical	30,992	1,291
Dental	4,680	195

[a] Based on 24 facilities. Does not include Morgantown, W.Va.
[b] Only 1 therapy facility in operation.

rate among inmates, annual physicals given to Justice Department employees, chest x rays to new inmates, and preemployment chest x rays for all personnel. Most of the fluoroscopic work was contracted out to local radiologists; hence, the fluoroscopic workload was low. As can be seen in table 1, the facility workloads (medical and dental) were relatively low. Although not shown in the table, the shielding (structural and added) of all facilities surveyed was found to be adequate for the workloads involved.

Table 2 presents the deficiencies noted on the diagnostic radiographic units surveyed. On 35.3 percent of the medical x-ray machines and 4.0 percent of the dental x-ray machines surveyed, the total filtration in the useful beam was found to be less than that required on the basis of the maximum tube potential. In each instance where this deficiency was noted, sufficient additional aluminum filtration was added to bring the total up to the value required by the maximum tube potential.

Table 2. Deficiencies noted for Bureau of Prisons diagnostic radiographic machines (medical and dental)

Deficiency	Number	Percent of machines surveyed that were deficient[a]
Total filtration required correction to meet appropriate standards		
Medical	12	35.3
Dental	1	4.0
Improper cone used, proper cone available		
Medical	4	11.8
Improper cone used, proper cone not available, variable collimator recommended		
Medical	7	20.6
Variable collimator present, operator not familiar with its use		
Medical	3	8.8
Beam diameter at cone tip exceeded 3 inches		
Dental	1	4.0
Timer inaccurate and/or exposure nonreproducible: Medical	1	2.9
Dental	17	68.0
Unsatisfactory operator protection		
Medical	10	29.4

[a] Based on 34 medical and 25 dental machines.

Inadequate collimation of the useful beam (in that the dimensions of the primary beam exceeded the dimensions of the film size used) was found on 32.4 percent of the medical x-ray machines surveyed. This was particularly true of those machines used almost exclusively for chest radiography.

Operator, personnel, and patient protection was found to be adequate at most fixed machine installations. In general, a lead-lined shield or booth was provided for the operator, and there was sufficient shielding to protect persons outside the x-ray room from scattered radiation. However, on 75 percent of the mobile x-ray machines the exposure switch cord length was such that it was not possible for the operator to stand at least 6 feet from the patient, the x-ray tube, and the useful beam. In each instance where the operator protection was found to be inadequate, recommendations were made which would correct the condition.

Table 3 lists the deficiencies noted on the fluoroscopes surveyed. The major deficiencies observed were the absence of Bucky-slot covers, failure of the diaphragm system to restrict the x-ray beam to the area of the viewing screen, and the absence of a protective drape between the patient and fluoroscopist to intercept scattered radiation. The high incidence of these three deficiencies may be used as an index of the age of the x-ray machines surveyed inasmuch as they are likely to be found on fluoroscopes manufactured prior to 1960. On machines manufactured after that date these appurtenances appear as standard equipment. The fact that the four fluoroscopes with no deficiencies had all been purchased within the past 4 years tends to support this thesis.

Table 3. Deficiencies noted on Bureau of Prisons fluoroscopic units

Deficiency	Number	Percent of machines surveyed[a]
Lead protective gloves and aprons not available or not used	1	5.9
Protective cover for Bucky-slot absent	7	41.2
Diaphragm system permits x-ray beam to exceed area of viewing screen	10	58.8
Manually reset cumulative timer to indicate elapsed time absent	1	5.9
Protective drape to intercept scattered radiation absent between patient and fluoroscopist	13	76.5

[a] Based on 17 facilities with fluoroscopes in operating condition.

In none of the fluoroscopes surveyed was the total filtration in the primary beam less than 2.5 mm aluminum equivalent. The exposure rate at the panel top of all fluoroscopes surveyed when operated at 80 kVp, was found to be equal to or less than 3.2 R/mA-min. There was no instance of excessive transmission of the x-ray beam through the viewing screen. As in the case of those radiographic machines where deficiencies were noted, recommendations were made for correction of the deficiencies.

Dental x-ray machine timer accuracy and/or reproducibility of exposures proved to be deficient in a surprisingly large number of cases. To be considered accurate, the timer should deliver exactly the exposure time for which it has been set. Reproducibility is the ability to give the same exposure time in successive tests in which the timer setting remains the same. Of the two, reproducibility is the most important from the standpoint of reducing unnecessary radiation exposure. By adjusting the timer setting, the operator can compensate for a timer that is known or suspected to be inaccurate, provided the exposure time is consistent in succeeding exposures. A timer that has poor reproducibility of exposures makes it almost impossible for the operator to compensate for this defect because of the variation in exposure time. Thus, the patient may receive unnecessary exposure from retakes necessitated by the unacceptable films produced as a result of the faulty timer.

The spinning top test which provides a visual comparison between x-ray pulse production and timer setting was used to measure timer system accuracy and exposure reproducibility. The test was performed on all dental x-ray machine timers. The timer settings checked in the test were those reported by the dentist or his assistant as being used for upper molars. Four successive tests were conducted at each setting using accuracy specifications described in the Federal specifications (*3*). "The timer shall be accurate to plus or minus 5 percent at any setting over 1 second, and plus or minus 10 percent at any setting under 1 second." Most dental x-ray exposure times are under 1 second; therefore, to be considered as having acceptable accuracy, the number of x-ray pulses observed on the developed film had to be within plus or minus 10 percent of the number of pulses equivalent to the timer setting.

Table 4. Accuracy and exposure reproducibility of Bureau of Prisons dental x-ray machine, timing systems at selected settings

Findings		Manufacturers			
Accuracy	Exposure reproducibility	Weber	Ritter	XRMC	Total
Acceptable	Acceptable	2	6	0	8
Acceptable	Unacceptable	0	0	0	0
Unacceptable	Acceptable	1	0	1	2
Unacceptable	Unacceptable	12	3	0	15
Total		15	9	1	25

Table 4 depicts the accuracy and reproducibility of the timing system on the dental x-ray machines surveyed. From these results, it can be seen that 15 of the 25 timing systems tested (60 percent) failed to meet the standards set for both accuracy and reproducibility. Two timers (8 percent) were inaccurate but had good reproducibility, and only 8 timers (32 percent) met the standard for both accuracy and reproducibility.

Although the number of machines and manufacturers covered during the survey may not constitute a representative sample, the data did indicate that timer accuracy and reproducibility were problems in machines produced by certain manufacturers. The timing systems on the two Weber x-ray machines that were acceptable for both accuracy and exposure reproducibility were replacement systems for defective original equipment.

The most notable deficiency observed during the surveys was that of operator training. At each of the facilities surveyed, the principal operator of the medical and dental x-ray equipment was an inmate technician who, as might be expected, had had no prior training in radiological technology. Although the medical-technical assistants assigned to each facility had had some formal training and experience in radiological technology, the duties assigned to these individuals made it almost impossible for them to devote much of their time to the training of inmate technicians. Because of the manner in which the on-the-job training of technicians was conducted, poor techniques tended to be passed from technician to technician. This fact was especially evident at those facilities with x-ray machines equipped with variable collimators. In general, the operators of these x-ray machines did not know how to use the collimator properly; therefore, its value as a mechanism for reducing unnecessary radiation exposure was correspondingly reduced.

Table 5. Facility information for the Federal Health Programs Service

Facility information	Information for facility not determined	Number of facilities reporting	Number	Average per facility
Personnel:				
Number of personnel occupationally exposed	4	27	239	8.9
Number of personnel monitored	7	24	282	11.7
Number of x-ray machine operators	3	28	210	7.5
Number of operators per machine			1.4	
Equipment:				
Total number of x-ray machines		31	148	4.8
Number of dental x-ray machines		31	44	1.4
Number of medical x-ray machines		31	104	3.4
Fixed radiographic		31	35	1.1
Radiographic-fluoroscopic		31	41	1.3
Mobile		31	22	.7
Photofluorographic		31	2	.06
Therapy		31	4	.1
Workload:				
Number of patients radiographed per year				
Medical		31	369,184	11,909
Dental		31	37,664	1,215
Number of exposures (film) per year				
Medical		31	907,648	29,279
Dental		31	140,816	4,542
Number of patients fluoroscoped per year	5	26	19,968	768
Number of therapy treatments per year		31	6,812	
Radiographic workload (mA-min/a)				
Medical	1	30	127,903	4,263
Dental	4	27	27,477	1,018

Federal Health Programs Service facilities

Table 5 summarizes the personnel, equipment, and machine workloads of the Federal Health Programs Service x-ray facilities surveyed. In general, each facility surveyed consisted of one or two dental x-ray machines and three or four medical x-ray machines. Of the 1,048,464 film exposures per year, 731,172 or 69.7 percent were reported by hospitals. The estimated number of patients per year reported by the hospitals was 257,608.

Table 6 presents the deficiencies noted on the diagnostic radiographic units surveyed (eight units were in storage or not used). For 2.2 percent of the medical machines surveyed, the total filtration in the useful beam was found to be less than that required on the basis of the maximum tube potential. Total filtration was adequate on all dental units. In each instance where this deficiency was noted, sufficient additional aluminum filtration was added to bring the total up to the value required by the maximum tube potential.

Inadequate collimation of the useful beam, in that the dimensions of the primary beam exceeded the dimensions of the film, was found on 3.3 percent of the medical x-ray machines surveyed.

Although 63 percent of the medical x-ray machines surveyed were equipped with a variable collimator which gave a visible indication of beam size, many of the operators of the machines did not know how to use the collimator correctly.

Table 6. Deficiencies noted on Federal Health Programs Service diagnostic radiographic machines

Deficiency	Number	Percent of machines surveyed[a]
Total filtration required correction to meet appropriate standards (medical)	2	2.2
Excessive beam size (medical)	3	3.3
Improper cone used, proper cone not available, variable collimator recommended (medical)	3	3.3
Variable collimator not functioning properly (medical)	4	4.3
No collimator or cones available (medical)	2	2.2
Beam diameter at cone tip exceeded 3 inches (dental)	0	0
Timer inaccurate and/or exposure nonreproducible: Medical	11	11.9
Dental	14	31.8
Unsatisfactory operator protection (medical)	5	5.4
Exposure control switch cord inadequate (mobile)	16	72.7

[a] Based on 92 medical and 44 dental machines.

X-ray machine timer accuracy and/or exposure reproducibility proved deficient in 11.9 percent of the medical x-ray units and 31.8 percent of the dental x-ray units.

Operator, personnel, and patient protection was found to be adequate at most fixed machine installations. In general, a lead-lined shield or booth was provided for the operator, and there was sufficient shielding to protect persons outside of the x-ray room from scattered radiation. However, on 72.7 percent of the mobile x-ray machines, the length of the exposure switch cord made it impossible for the operator to stand at least 6 feet from the patient, the x-ray tube, and the useful beam. In each instance where operator protection was found to be inadequate, recommendations were made to correct the condition.

Table 7 lists the deficiencies noted on the fluoroscopes surveyed. Four of the 41 fluoroscopes were not used. The major deficiencies observed were the absence of Bucky-slot covers, failure of the diaphragm system to restrict the x-ray beam to the area of the viewing screen, and the absence of a protective drape between the patient and fluoroscopist to intercept scattered radiation.

Table 7. Deficiencies noted on Federal Health Programs Service fluoroscopic units

Deficiency	Number	Percent of machines surveyed[a]
Leaded protective gloves not available or not used	1	2.7
Protective cover for Bucky-slot absent	7	18.9
Diaphragm system permits x-ray beam to exceed area of viewing screen	4	10.8
Manually reset cumulative timer to indicate elasped time absent	2	5.4
Protective drape to intercept scattered radiation absent between patient and fluoroscopist	10	27.0
Excessive transmission of x-ray beam through viewing screen	1	2.7
Total filtration in useful beam less than 2.5 mm aluminum equivalent	1	2.7
Exposure rate at panel top greater than 3.2 R/mA-min when operated at 80 kVp	0	0

[a] Based on 37 fluoroscopes.

The high incidence of these three deficiencies indicates the age of the x-ray machines surveyed inasmuch as they are likely to be found on fluoroscopes manufactured prior to 1960.

In only one of the machines surveyed was the total filtration in the primary beam less than 2.5 mm aluminum equivalent. The exposure rate at the panel top of all fluoroscopes surveyed was found to be equal to or less than 3.2 R/mA-min when operated at 80 kVp. There was one instance of excessive transmission of the x-ray beam through the viewing screen. As in the case of those radiographic machines on which deficiencies were noted, recommendations for correction of the deficiencies were made.

Only four therapy machines were surveyed, and no deficiencies were found.

One of the most important deficiencies observed during the surveys was that of operator training. This problem occurred primarily in smaller installations where a medical technician was required to double as an x-ray technician with little or no formal training. On the other hand, the large installations quite often had an overabundance of trained x-ray technicians who could have been used elsewhere.

Conclusions

An analysis of the data collected revealed that the major problem areas are inadequate training of x-ray machine operators and the modification of existing equipment so that it meets currently accepted standards.

The following actions have been taken to correct the deficiencies:

1. Radiation safety courses
   a. Bureau of Prisons: A radiation safety course for Medical Technical Assistants was presented at the Medical Center, Springfield, Mo., during March 1970.
   b. Federal Health Programs Service: A radiation safety course was presented at Staten Island, N.Y., during March 1970.
2. Modifications to equipment have been made as recommended.
3. The Weber Dental Company was notified of the deficiencies in its machines; attempts at corrective action are in progress.
4. The facility survey agreements were renegotiated; the surveys will be repeated at a regular frequency.

The mention of commercial products is not to be construed as either an actual or implied endorsement of such products by the Department of Health, Education, and Welfare.

REFERENCES

(*1*) NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS. Medical X-ray and Gamma-ray Protection for Energies up to 10 MeV. Equipment Design and Use, NCRP Report No. 33. National Council on Radiation Protection and Measurements, Washington, D.C. 20008 (February 1968).

(*2*) U.S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS. Medical X-ray Protection up to Three Million Volts, NBS Handbook 76. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (February 1961).

(*3*) GENERAL SERVICES ADMINISTRATION. Federal Specifications X-ray Apparatus, GG-X-620, paragraph (timers) 3.4.2.1 (December 7, 1954).

Color Television Survey in Pennsylvania

Richard A. Lane[1]

During 1968–1970, 322 color television sets in Pennsylvania were surveyed for emission of x radiation. Eighty-eight percent were found to emit radiation less than or equal to 0.1 mR/h at 5 cm. Two percent emitted radiation in excess of 0.5 mR/h. It was determined from the survey that the primary cause for excess radiation from color television sets is related to high voltage adjustments. It was found that two of the sets emitting radiation in excess of 0.5 mR/h were serviced shortly before the investigation. Voltage readings as high as 39 kV were observed.

On October 18, 1968, the 90th Congress of the United States enacted Public Law 90-602 entitled the "Radiation Control for Health and Safety Act of 1968." Shortly thereafter, standards for radiation emission for color television sets were published in the Federal Register (*1*). These standards state that the radiation exposure rate in air 5 cm from any point on the external surface of a television receiver shall not exceed 0.5 mR/h.

Following the publication of a newspaper article, the Office of Radiological Health of the Pennsylvania Department of Health received 343 requests for x-ray surveys of color television sets. Requests were honored until February 23, 1970. Subsequently, persons requesting surveys received a letter giving the results of this survey, recommendations for proper viewing of color television and the suggestion that a serviceman check the set for proper electrical operation. Of the 343 requests received, 322 color television sets were surveyed.

The survey instruments used during the survey were end-window Thyac II GM counters and Victoreen 440 RF ion chambers. The readings from the GM counters were found to be in close agreement with the ion-chambers. However, the GM counters were not calibrated for the specific energy levels associated with color television.

Two hundred and eighty-two sets (87.6 percent) were found to emit radiation less than or equal to 0.1 mR/h. Thirty-three sets (10 percent) emitted radiation at levels greater than 0.1 but less than 0.5 mR/h. Seven sets (2 percent) emitted radiation in excess of 0.5 mR/h. Table 1 shows the breakdown by manufacturers of the sets involved in the survey. Of the seven sets which had readings in excess of 0.5 mR/h, five were manufactured by RCA. It is important, however, to note that RCA was the manufacturer of approximately one-third of all sets inspected.

By previous arrangements, RCA was notified of the five RCA sets emitting radiation in excess of 0.5 mR/h found in the survey. Representatives of RCA and a representative from the Office of Radiological Health, Pennsylvania Department of Health, visited the residences of the individuals possessing these sets. Only three of the individuals could be contacted by either RCA or the Office of Radiological Health to establish appointments. In all three cases, the sets were measured by both RCA and the Office of Radiological Health representative using Victoreen 440 RF ion chambers. In all instances, the measurements

---

[1] Mr. Lane is the radiation health physicist with the Office of Radiological Health, Pennsylvania Department of Health, P.O. Box 90, Harrisburg, Pa. 17120

141

Table 1. Results of color television survey Pennsylvania, 1968-1970

Manufacturers	Number of sets			Model and year
	≤0.1 mR/h	>0.1–<0.5 mR/h	>0.5 mR/h	
Admirial	19	0	1 (1.0 mR/h)	1965
Dumont	1	1	0	
General Electric	18	1	0	
Heathkit	1	0	0	
JVC Nivico Vision	2	0	0	
Magnavox	15	0	0	
Motorola	22	1	0	
Olympic	1	1	0	
Philco	19	3	0	
RCA	99	17	5 (2.0 mR/h) (.7 mR/h) (2.5 mR/h) (3.0 mR/h) (1.0 mR/h)	GG583W 1965 Unknown 1965 GJ705W 1965 GJ705W 1968 8322-6 1968
Sears	17	0	0	
Sharp	1	0	0	
Sylvania	9	1	0	
Westinghouse	1	0	0	
Zenith	57	8	1 (1.0 mR/h)	Unknown
Total	282	33	7	
Grand total	322			

agreed with the initial reading determined by the previous survey. Measurements indicated that the line voltage to the three sets involved was 119 volts. The high voltage output to the picture tube was 29 kV, 37 kV, and 39 kV, respectively. Increasing the high voltage output tends to give a brighter picture, a temporary step and one that should not be taken. It was interesting to note that the two sets having the highest voltage had been serviced by a repairman within the preceding 2 weeks. The RCA representatives reduced the voltage to 24.5 kV and made other necessary adjustments to produce a picture satisfactory to the owners. After the final adjustments were completed, a radiation emission survey of the sets was made. In all three cases, readings of less than or equal to 0.1 mR/h were observed.

Summary

The survey of color television sets in Pennsylvania showed that only 2 percent of the sets surveyed emitted radiation higher than the standard of 0.5 mR/h at 5 cm from the set. Two out of three sets emitting excessive radiation were found to have the high voltage far in excess of that specified by the manufacturer. It appears that television servicemen need to be reminded that improper adjustment of the high voltage on a color television set can create a radiation hazard.

Other causes of excessive radiation emission, such as defective shunt regulator tubes and lack of proper radiation shielding, were not observed during the survey.

The following recommendations appear appropriate for Pennsylvania color television owners:

1. Color television sets purchased before January 15, 1970, should be viewed from a distance of at least 6 feet; television sets purchased after that date must meet more stringent standards and should not present a radiation problem (*2*), and
2. Only qualified persons should repair or service the set.

REFERENCE

(*1*) PUBLIC HEALTH SERVICE, DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE. Performance standard for television receivers. Federal Register 34:20, 273-275 (December 25, 1969).

(*2*) PUBLIC HEALTH SERVICE, DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE. What's being done about x-rays from home TV sets, BRH/P5. Bureau of Radiological Health, Rockville, Md. 20850 (January 1971).

Technical Notes

Strontium-90 and Cesium-137 Levels in the Diet of Children on a School Lunch Program

P. S. Weng and *C. N. Hsu*[1]

The school lunch program supported by the United Nations is a special project at Hsinchu, Taiwan, Republic of China, to provide the primary school children with a nutritious lunch containing flour products as the main course. The flour products are made primarily from wheat imported from the United States, Canada, and Australia. It is contrary to the diet of adults who prefer to have rice and soup for their lunch, and a comparison of the fallout nuclides in the lunches of school children and adults is thus investigated.

Since 1969, school children's lunches at a nearby primary school have been sampled daily except weekends, holidays, and vacations. The analysis of adult lunch has long been a routine survey at Tsing Hua University, and the sampling is taken at the University's cafeteria. Radiochemical methods (*1*) are used to determine the nuclides existing in the diet with reference to strontium-90, cesium-137, potassium, and calcium.

Figure 1 shows the average daily intake of strontium-90 and cesium-137 during the observation periods. The comparison of average strontium-90 and cesium-137 concentrations in school children's lunch and in an adults' lunch is shown in table 1. Though the counting error is within 15 percent, the activities in the school children's lunch still show higher values than those in the adults' lunch. This may be attributed to the imported wheat which has a higher fallout content than the locally grown rice.

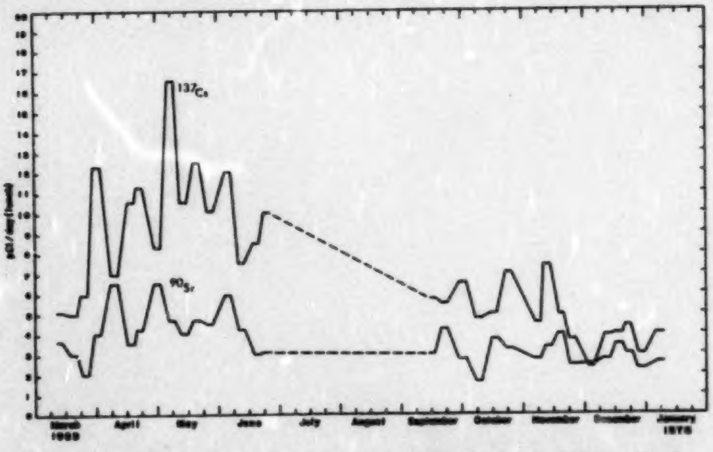


Figure 1. Daily intake of strontium-90 and cesium-137 in school children's lunch at Hsinchu, Taiwan Republic of China

---

[1] Mr. Weng and Mr. Hsu are with the Health Physics Section, National Tsing Hua University, Hsinchu, Taiwan, Republic of China.

Table 1. The comparison of average strontium-90 and cesium-137 concentration in school children's lunch and in adults' lunch in Hsinchu, Taiwan, Republic of China

Lunch	Potassium		Cesium-137			Calcium	
	$\left(\frac{mg}{100mg\text{-}ash}\right)$	$\left(\frac{g}{kg\text{-}fresh}\right)$	$\left(\frac{pCi}{g\text{-}ash}\right)$	$\left(\frac{pCi}{kg\text{-}fresh}\right)$	$\left(\frac{pCi}{g\ K}\right)$	$\left(\frac{mg}{100mg\text{-}ash}\right)$	$\left(\frac{g}{kg\text{-}fresh}\right)$
School children's lunch	9.96	0.96	0.70	6.75	7.03	3.42	0.33
Adult's lunch	7.72	.71	.33	2.94	4.15	2.47	.23

Lunch	Strontium-90			$\left(\frac{^{137}Cs}{^{90}Sr}\right)$	Total gross beta activity	
	$\left(\frac{pCi}{g\text{-}ash}\right)$	$\left(\frac{pCi}{kg\text{-}fresh}\right)$	$\left(\frac{pCi}{g\text{-}Ca}\right)$		$\left(\frac{pCi}{g\text{-}ash}\right)$	$\left(\frac{pCi}{kg\text{-}fresh}\right)$
School children's lunch	0.37	3.57	10.82	1.80	75.47	728.39
Adult's lunch	.23	2.11	9.31	1.38	59.85	549.80

REFERENCE

(1) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures, NYO-4700. U.S. Atomic Energy Commission, Health and Safety Laboratory, New York, N. Y. (1967).

Data

SECTION I. MILK AND FOOD

Milk Surveillance, November 1970

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Radiation Office, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabo-

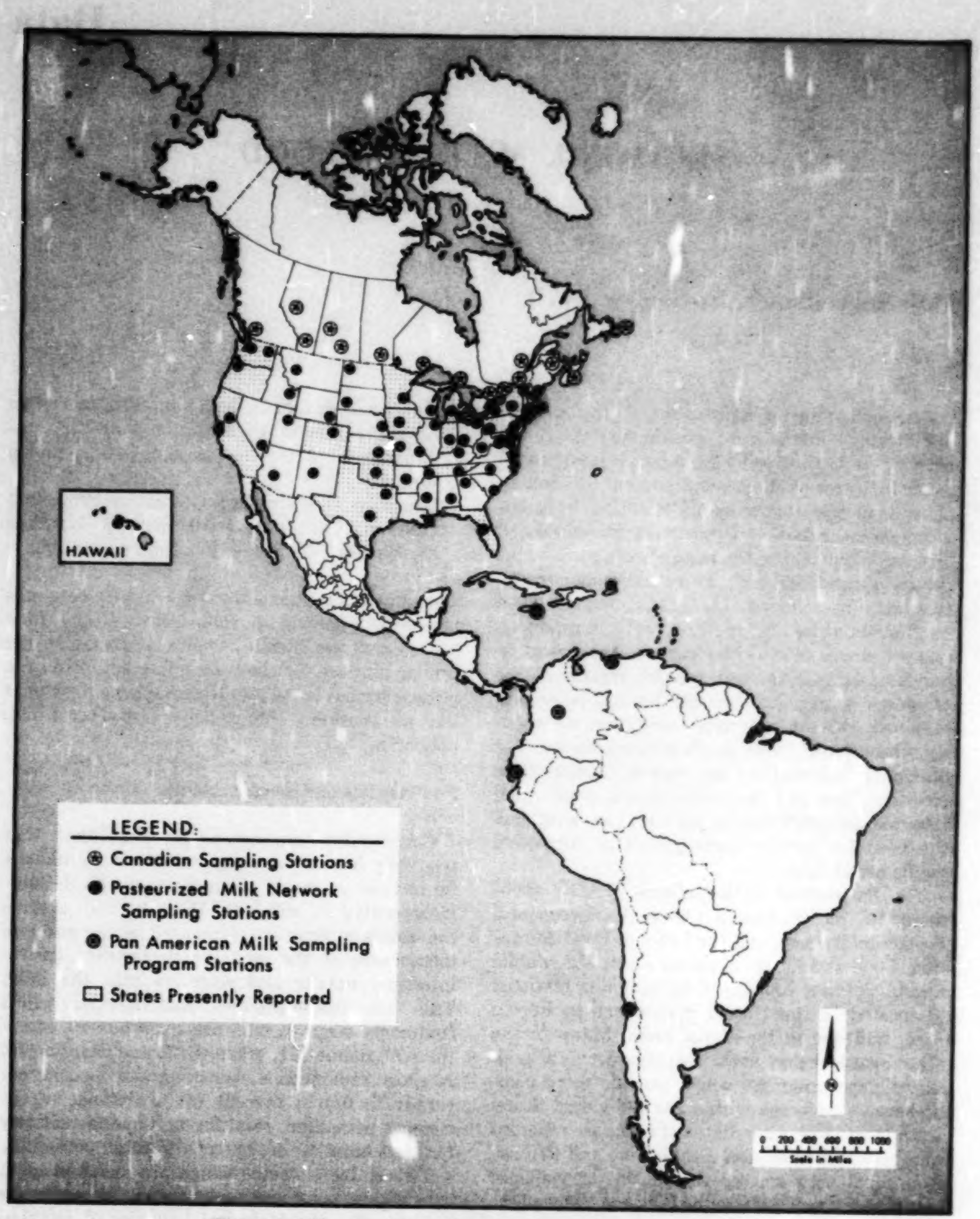

HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
◉ Pan American Milk Sampling Program Stations
▨ States Presently Reported
0 200 400 600 800 1000
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere

lically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2-standard deviations (2σ), for these elements are 1.16±0.08 g/liter for calcium and 1.51±0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Radiation Office conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during May-July 1970, with 28 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 (*5*). Of the 20 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 13 participated in the experiment.

The accuracy results of this experiment are shown in table 1. In general, considerable improvement is needed, especially in the accuracy measurements. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category			
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Strontium-89: High (258 pCi/liter)	7 (44%)	1 (6%)	8 (50%)	16
Low (15 pCi/liter)	11 (69%)	3 (19%)	2 (12%)	16
Strontium-90: Intermediate (79.4 pCi/liter)	13 (57%)	4 (17%)	6 (26%)	23
Low (32.0 pCi/liter)	5 (25%)	4 (20%)	11 (55%)	20
Iodine-131: High (507 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
Low (49 pCi/liter)	16 (64%)	3 (12%)	6 (24%)	25
Cesium-137: High (250 pCi/liter)	20 (74%)	3 (11%)	4 (15%)	27
Low (53 pCi/liter)	17 (66%)	5 (19%)	4 (15%)	26
Barium-140: High (302 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
Low (33 pCi/liter)	23 (92%)	0	2 (8%)	25

[a] Measured concentration less than or equal to 2σ of the known concentration.
[b] Measured concentration greater than 2σ and less than or equal to 3σ of the known concentration.
[c] Measured concentration greater than 3σ of the known concentration.

been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short time periods, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data presentation (table 2) also reflects whether raw or pasteurized milk was collected. An analysis of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that, for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels are given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity

Table 2. Concentrations of radionuclides in milk for November 1970 and 12-month period December 1969 through November 1970

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	NA	6	0	0	0	8
Alaska:	Palmer[c]	P	7	6	0	0	17	10
Ariz:	Phoenix[c]	P	NA	1	0	0	0	0
Ark:	Little Rock[c]	P	12	13	0	0	12	17
Calif:	Sacramento[c]	P	NA	2	0	0	0	0
	San Francisco[c]	P	NA	2	0	0	0	0
	Del Norte	P	12	18	0	0	14	15
	Fresno	P	2	2	0	0	0	2
	Humboldt	P	4	5	0	0	8	5
	Los Angeles	P	1	2	0	0	0	2
	Mendocino	P	1	4	0	0	0	2
	Sacramento	P	2	2	0	0	0	2
	San Diego	P	2	2	0	0	0	1
	Santa Clara	P	2	2	0	0	0	1
	Shasta	P	4	3	0	0	6	2
	Sonoma	P	2	3	0	0	2	2
Colo:	Denver[c]	P	NA	5	0	0	0	1
	West	R	(d)		NS	(e)0	NS	4
	Northeast	R	(d)		(e)0 (8)	(e)0	(e)0 (8)	(e)0
	East	R	(d)		(e)0	(e)0	(e)0	(e)0
	Southeast	R	(d)		NS	(e)0	NS	(e)0
	South Central	R	(d)		NS	NS	NS	NS
	Southwest	R	(d)		NS	(e)0	NS	7
	Northwest	R	(d)		NS	6	NS	0
Conn:	Hartford[c]	P	NA	8	0	0	0	11
	Central	P	8	7	0	0	16	14
Del:	Wilmington[c]	P	NA	9	0	0	0	7
D.C:	Washington[c]	P	NA	7	0	0	0	6
Fla:	Tampa[c]	P	6	5	0	0	47	51
	West	R	5	9	0	0	22	17
	North	R	5	10	0	0	30	24
	Northeast	R	7	6	0	0	44	43
	Central	R	6	7	0	0	19	56
	Tampa Bay area	R	5	6	0	0	49	50
	Southeast	R	8	7	14	1	136	75
Ga:	Atlanta[c]	P	NA	10	0	0	12	16
Hawaii:	Honolulu[c]	P	0	2	0	0	0	0
Idaho:	Idaho Falls[c]	P	4	5	0	0	20	6
Ill:	Chicago[c]	P	7	7	0	0	0	10
Ind:	Indianapolis[c]	P	NA	8	0	0	0	6
	Northeast	P	12	10	0	1	15	14
	Southeast	P	11	11	0	0	10	12
	Central	P	9	9	0	0	0	10
	Southwest	P	10	12	0	0	10	12
	Northwest	P	14	11	3	0	15	14
Iowa:	Des Moines[c]	P	NA	7	0	0	0	2
	Iowa City	P	4	7	0	0	11	11
	Des Moines	P	6	8	0 (4)	0	15 (4)	8
	Spencer	P	6	6	0	0	15	7
	Fredericksburg	P	NS	NS	NS	NS	NS	NS
Kans:	Wichita[c]	P	NA	8	0	0	12	3
	Coffeyville	P	9	9	21	2	13	1
	Dodge City	P	8	7	0	0	10	2
	Falls City	R	5	7	16	3	11	4
	Hays	P	12	14	0	1	0	1
	Kansas City	P	6	8	0	0	12	4
	Topeka	P	13	10	19	2	0	3
	Wichita	P	10	12	0	0	10	1
Ky:	Louisville[c]	P	NA	8	0	0	0	4
La:	New Orleans[c]	P	14	15	0	0	20	19
Maine:	Portland[c]	P	NA	10	0	0	22	22
Md:	Baltimore[c]	P	NA	7	0	0	0	7
Mass:	Boston[c]	P	10	10	0	0	19	21
Mich:	Detroit[c]	P	NA	8	0	0	0	8
	Grand Rapids[c]	P	NA	9	0	0	0	11
	Bay City	P	NS	7	NS	(e)0	NS	9
	Charlevoix	P	NA	13	(e)0 (4)	(e)1	13 (4)	16
	Detroit	P	NA	8	(e)0	(e)0	13	8
	Grand Rapids	P	NA	9	(e)0	(e)0	13	9
	Lansing	P	NA	9	(e)0 (3)	(e)0	13 (3)	14
	Marquette	P	NA	14	(e)0 (2)	(e)0	21 (2)	23
	Monroe	P	NA	6	(e)0 (2)	(e)0	0 (2)	3
	South Haven	R	NA	8	(e)0 (5)	(e)0	8 (5)	7
Minn:	Minneapolis[c]	P	NA	9	0	0	21	10
	Bemidji	P	8	10	0	0	15	21
	Mankato	P	4	4	0	0	0	11
	Rochester	P	7	6	0	0	0	11
	Duluth	P	14	14	0	0	22	27
	Worthington	P	4	4	0	0	0	0
	Minneapolis	P	11	9	0	0	18	16
	Fergus Falls	P	5	6	0	0	17	13
	Little Falls	P	20	11	0	0	25	33

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for November 1970 and 12-month period December 1969 through November 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
Miss:	Jackson[c]	P	NA	12	0	0	11	12
Mo:	Kansas City[c]	P	NA	8	0	0	0	2
	St. Louis[c]	P	NA	8	0	0	0	4
Mont:	Helena[c]	P	NA	5	0	0	0	6
Nebr:	Omaha[c]	P	NA	5	0	0	0	1
Nev:	Las Vegas[c]	P	NA	2	0	0	0	0
N.H:	Manchester[c]	P	NA	9	0	0	18	19
N.J:	Trenton[c]	P	NA	7	0	0	0	9
N. Mex:	Albuquerque[c]	P	NA	4	0	0	0	0
N.Y.	Buffalo[c]	P	6	7	0	0	12	9
	New York City[c]	P	NA	10	0	0	18	16
	Syracuse[c]	P	NA	7	0	0	0	9
	Albany	P	7	6	0 (4)	0	0 (4)	0
	Buffalo	P	(e)0	(e)0	0	0	0	0
	Massena	P	9	7	0 (2)	0	0 (2)	0
	Newburg	P	5	6	0 (4)	0	0 (4)	0
	New York City	P	14	10	0	0	0	0
	Syracuse	P	7	3	0 (2)	0	0 (2)	0
N.C:	Charlotte[c]	P	NA	11	0 (2)	0	14 (2)	18
N. Dak:	Minot[c]	P	NA	10	0	0	13	14
Ohio:	Cincinnati[c]	P	NA	8	0	0	0	4
	Cleveland[c]	P	NA	9	0	0	12	10
Okla:	Oklahoma City[c]	P	NA	6	0	0	11	6
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Oreg:	Portland[c]	P	5	5	0	0	0	5
	Baker	P	NA	4	(e)0	(e)0	(e)0	5
	Coos Bay	P	NA	6	(e)0	(e)0	(e)0	12
	Eugene	P	NA	3	(e)0	(e)0	(e)0	4
	Medford	P	NA	3	(e)0	(e)0	(e)0	8
	Portland composite	P	NA	0	(e)0	(e)0	NA	8
	Portland local	P	NA	5	(e)0	(e)0	NA	6
	Redmond	P	NA	5	(e)0	(e)0	(e)0	3
	Tillamook	P	NA	7	(e)0	(e)0	(e)0	16
Pa:	Philadelphia[c]	P	NA	9	0	0	12	6
	Pittsburgh[c]	P	NA	11	0	0	12	12
	Dauphin	P	8	7	0	0	15	13
	Erie	P	12	12	0	0	41	27
	Philadelphia	P	11	8	0	0	19	13
	Pittsburgh	P	15	22	0	0	22	20
R. I:	Providence[c]	P	NA	9	0	0	14	16
S. C:	Charleston[c]	P	8	0	0	1	19	19
S. Dak:	Rapid City[c]	P	NA	7	0	0	0	5
Tenn:	Chattanooga[c]	P	NA	9	0	0	15	10
	Memphis[c]	P	NA	9	0	0	0	7
	Chattanooga	P	6	9	0	0	11	14
	Clinton	P	7	12	0 (2)	0	15 (2)	14
	Fayetteville	P	8	12	0 (2)	0	17 (2)	13
	Knoxville	P	5	7	0 (2)	0	17 (2)	10
	Nashville	P	3	7	0	0	14	9
Tex:	Austin[c]	P	NA	2	0	0	0	3
	Dallas[c]	P	NA	6	0	0	0	6
	Amarillo	R	NS	4	NS	0	NS	2
	Corpus Christi	R	3	4	0	0	0	2
	El Paso	R	NS	3	NS	0	NS	3
	Fort Worth	R	NS	5	NS	0	NS	0
	Harlingen	R	NS	3	NS	0	NS	0
	Houston	R	NS	6	NS	0	NS	14
	Lubbock	R	NS	4	NS	0	NS	0
	Midland	R	NS	2	NS	0	NS	0
	San Antonio	R	NS	4	NS	0	NS	0
	Texarkana	R	NS	8	NS	0	NS	0
	Tyler	R	NS	15	NS	0	NS	17
	Uvalde	R	NS	2	NS	0	NS	0
	Wichita Falls	R	5	9	0	0	0	2
Utah:	Salt Lake City[c]	P	NS	4	NS	0	NS	7
Vt:	Burlington[c]	P	NA	8	0	0	20	13
Va:	Norfolk[c]	P	NA	9	0	0	0	8
Wash:	Seattle[c]	P	NA	5	0	0	15	3
	Spokane[c]	P	NA	6	0	0	11	2
	Benton County	R	0	0	0	0	13	5
	Franklin County	R	NS	1	NS	0	NS	3
	Sandpoint, Idaho	R	11	10	0	0	16	20
	Skagit County	R	10	6	0	0	13	8
W. Va:	Charleston[c]	P	NA	8	0	0	0	4
Wisc:	Milwaukee[c]	P	NA	6	0	0	0	11
Wyo:	Laramie[c]	P	NA	5	0	0	0	1

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for November 1970 and 12-month period, December 1969 through November 1970—Continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)					
		Strontium-90		Iodine-131		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA:							
Alberta: Calgary	P	NA		NA		18	17
Edmonton	P	NA		NA		17	19
British Columbia:							
Vancouver	P	NA		NA		22	26
Manitoba: Winnipeg	P	NA		NA		23	27
New Brunswick:							
Fredericton	P	NA		NA		22	22
Newfoundland:							
St. John's	P	NA		NA		22	35
Nova Scotia:							
Halifax	P	NA		NA		25	21
Ontario: Ottawa	P	NA		NA		11	14
Sault Ste. Marie	P	NA		NA		31	32
Ontario: Thunder Bay	P	NA		NA		29	29
Toronto	P	NA		NA		14	10
Windsor	P	NA		NA		18	10
Quebec: Montreal	P	NA		NA		14	18
Quebec	P	NA		NA		26	26
Saskatchewan:							
Regina	P	NA		NA		16	14
Saskatoon	P	NA		NA		15	14
CENTRAL AND SOUTH AMERICA:							
Colombia: Bogota	P	3	0	0	0	0	0
Chile: Santiago	P	NS	0	NS	0	NS	0
Ecuador: Guayaquil	P	4	0	0	0	0	0
Jamaica: Mandeville	P	NS	5	NS	0	NS	81
Venezuela: Caracas	P	2	2	0	0	0	0
Canal Zone:							
Cristobal[c]	P	NA	1	0	0	12	9
Puerto Rico:							
San Juan[c]	P	NA	4	0	0	0	7
PMN network average[f]		8	7	0	0	7	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the radionuclides reported gives the monthly average for the station and in parentheses, the number of samples analyzed in that month. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than

151

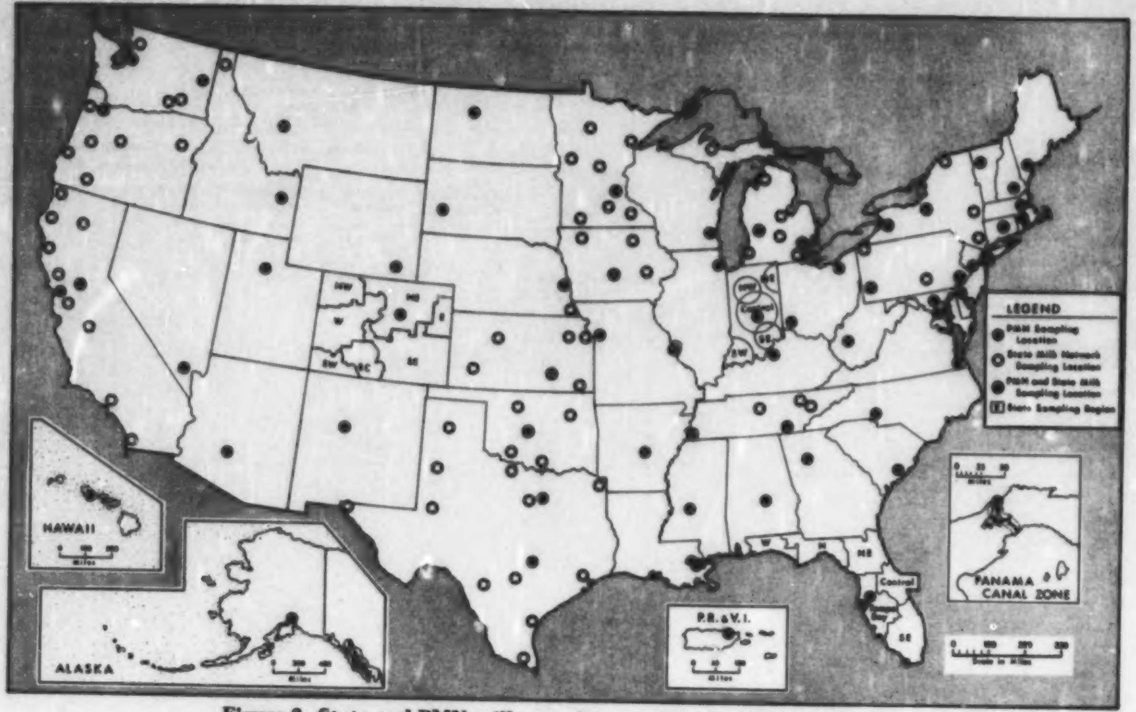


Figure 2. State and PMN milk sampling stations in the United States

the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed populations groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90, iodine-131, and cesium-137 for November 1970 and the 12-month period, December 1969 through November 1970. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for November 1970 were below the respective practical reporting levels. The following station averages reflect samples in which strontium-89 and barium-140 were detected: strontium-89, Kans., Topeka (State) 6 pCi/liter; barium-140 Fla., Southeast (State) 12 pCi/liter.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower guide levels established by the Federal Radiation Council, levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 20 pCi/liter in the United States for November 1970 and the highest 12-month average was 22 pCi/liter (Pittsburgh, Pa., State) representing 11.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 136 pCi/liter in the

United States for November 1970 and the highest 12-month average was 75 pCi/liter (Southeast Florida) representing 2.1 percent of the value derived from the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica. Iodine-131 results for individual samples were all below the practical reporting level with the following exceptions: Florida, Southeast (State), 14 pCi/liter; Kansas, Coffeyville (State), 21 pCi/liter, Falls City (State), 16 pCi/liter, Topeka (State), 19 pCi/liter.

As of July 1, 1970, the collection frequency of the PMN was reduced from weekly to quarterly because of lack of variations in the data. Provisions have been made to increase the collection frequency if warranted by the situation.

Gamma spectroscopy will continue to be performed on all samples. Strontium-89 and strontium-90 analyses will be performed on samples from 12 selected stations each month, and strontium-89 and strontium-90 analyses will be performed on all samples on a quarterly basis. The 12 selected stations are Boston, Mass; Buffalo, N.Y; Chicago, Ill; Charleston, S.C; Little Rock, Ark; New Orleans, La; Tampa, Fla; Idaho Falls, Idaho; Portland, Oreg; Salt Lake City, Utah; Palmer, Alaska; and Honolulu, Hawaii.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiological Health Section
Division of Air, Occupational and
Radiological Health
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational
Health Section
Department of Health and
Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Nuclear Engineering
New York State Department of
Environmental Conservation

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

REFERENCES

(1) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Public Health 49:225 (February 1959).

(2) Chart of the Nuclides, Ninth Edition revised to July 1966. Knolls Atomic Power Laboratory (November 1966).

(3) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

(4) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(5) KNOWLES, F. Interlaboratory study of iodine-131, cesium-137, barium-140, strontium-89, and strontium-90 measurements in milk, May–July 1970 Technical experiment 70–MKAQ–1, Analytical Quality Control Service, Bureau of Radiological Health (September 1970).

(6) NEILL, R. H. and D. R. SNAVELY. State Health Department sampling criteria for surveillance of radioactivity in milk. Radiol Health Data Rep 8:621–627 (November 1967).

(7) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

(8) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER, and B. KAHN. The cause of relatively high cesium-137 concentrations in Tampa, Florida, milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y., (1966) pp. 95–101.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiological Health Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January–June 1970	November 1970
Carbon-14 and Tritium in Total Diet and Milk	January 1969–June 1970	January 1971
Connecticut Standard Diet	July–December 1969	December 1970
Institutional Diet Samples	July–September 1970	February 1971
Strontium-90 in Tri-City Diets	January–December 1969	June 1970

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (2–4), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	July–December 1968	August 1970
Coast Guard	January 1968–July 1969	February 1970
Interstate Carrier Drinking Water	1967–1969	December 1970
Kansas	January–December 1969	September 1970
Minnesota	January–June 1969	January 1970
North Carolina	January–December 1967	May 1969
New York	January–June 1969	June 1970
Radiostrontium in Tap Water, *HASL*	January–December 1969	July 1970
Tritium in Community Water Supplies	1969	December 1970
Tritium in Surface Waters	January–June 1970	November 1970
Washington	January–June 1969	June 1970

---

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidence for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
Fallout in the United States and Other Areas, *HASL*	July 1968–December 1969	January 1971
Plutonium in Airborne Particulates and Precipitation, *PHS*	April–December 1969	October 1970
Surface Air Sampling Program, *HASL*	January–December 1967	January 1971

156

1. Radiation Alert Network
November 1970

Air Pollution Control Office
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State Health Department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Data Acquisition and Analysis Branch, Division of Air Quality and Emission Data, EPA, Cincinnati, Ohio. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during November 1970. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

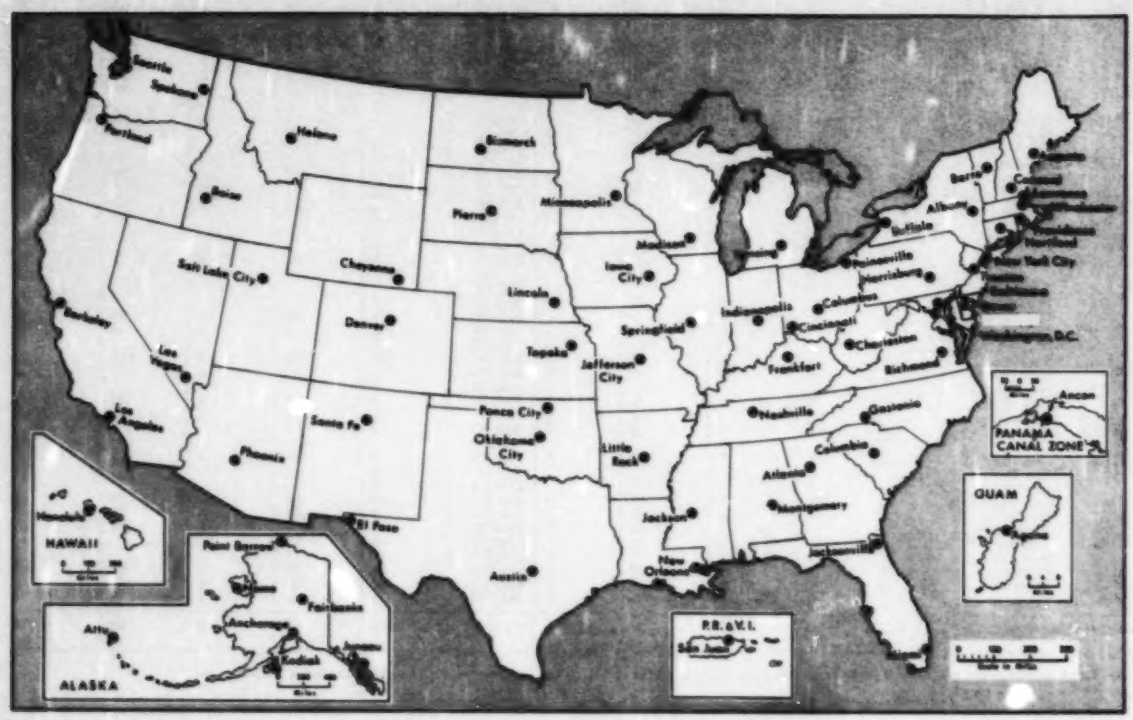

Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Salt Lake City
Cheyenne
Lincoln
Berkeley
Denver
Topeka
Las Vegas
Jefferson City
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Phoenix
El Paso
Austin
Honolulu
HAWAII
Point Barrow
Fairbanks
Anchorage
Attu
Kodiak
Juneau
ALASKA
Madison
Iowa City
Lansing
Springfield
Indianapolis
Columbus
Cincinnati
Frankfort
Charleston
Richmond
Painesville
Harrisburg
Buffalo
Albany
Barre
Augusta
Concord
Providence
Hartford
New York City
Baltimore
Washington, D.C.
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Jackson
Little Rock
New Orleans
Jacksonville
Ancon
PANAMA CANAL ZONE
GUAM
Agana
P.R. & V.I.
San Juan

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, November 1970

Station location		Gross beta radioactivity (5-hour field estimate) (pCi/m³)				Last profile in RHD&R	Precipitation				
									Field estimation of deposition		
		Number of samples	Maximum	Minimum	Average[a]		Number of samples	Total depth (mm)	Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	19	4	0	1	Oct 70	2	41	2	41	2
Alaska:	Anchorage	0				Feb 71	0				
	Attu Island	20	0	0	0	Nov 70	0				
	Fairbanks	18	1	0	0	Mar 71	10	59	10	59	27
	Juneau	2	[b]27	[b]21	[b]26	Aug 70	0				
	Kodiak	6	0	0	0	Sept 70	0				
	Nome	22	1	0	0	Dec 70	0				
	Point Barrow	0				Nov 70	0				
Ariz:	Phoenix	12	11	2	5	Aug 70	0				
Ark:	Little Rock	10	2	0	1	Mar 71	0				
Calif:	Berkeley	18	1	0	0	Sept 70	6	144	6	144	3
	Los Angeles	18	6	0	1	Dec 70	0				
C.Z.:	Ancon	0				Sept 70	0				
Colo:	Denver	17	6	0	2	Sept 70	5	25	(c)		
Conn:	Hartford	17	1	0	0	July 70	8	49	8	40	1
Del:	Dover	18	1	0	0	Feb 71	0				
D.C.:	Washington	24	1	0	0	Dec 70	0				
Fla:	Jacksonville	17	2	0	1	Mar 71	2	9	2	9	1
	Miami	10	0	0	0	July 70	1	20	1	20	0
Ga:	Atlanta	16	1	1	1	Jan 71	1	98	1	98	24
Guam:	Agana	0				Feb 71	0				
Hawaii:	Honolulu	23	1	0	0	Nov 70	9	93	(c)		
Idaho:	Boise	19	4	0	1	Nov 70	8	63	8	63	3
Ill:	Springfield	6	2	0	1	Dec 70	0				
Ind:	Indianapolis	17	1	0	0	Jan 71	0				
Iowa:	Iowa City	17	6	0	1	Sept 70	2	16	2	16	0
Kans:	Topeka	18	3	0	1	Mar 71	6	27	6	27	0
Ky:	Frankfort	0				Dec 70	0				
La:	New Orleans	16	1	0	0	Aug 70	5	23	(c)		
Maine:	Augusta	5	2	0	1	Jan 71	2	25	1	(b)	0
Md:	Baltimore	17	2	0	0	July 70	6	54	6	54	0
Mass:	Lawrence	18	1	0	0	Sept 70	8	109	8	109	0
	Winchester	19	1	0	1	Oct 70	7	90	7	90	0
Mich:	Lansing	16	1	0	0	Nov 70	6	47	6	47	6
Minn:	Minneapolis	18	2	0	0	Feb 71	7	148	7	148	16
Miss:	Jackson	14	2	0	0	Aug 70	2	24	2	24	0
Mo:	Jefferson City	18	3	0	1	Jan 71	2	28	2	28	0
Mont:	Helena	15	3	0	1	Oct 70	3	12	3	12	0
Nebr:	Lincoln	11	5	1	2	Jan 71	1	4	1	4	1
Nev:	Las Vegas	17	3	1	2	July 70	0				
N.H.:	Concord	0				Dec 70	0				
N.J.:	Trenton	17	1	0	0	Aug 70	9	122	9	122	1
N.Mex:	Santa Fe	16	3	0	1	Oct 70	2	5	2	5	0
N.Y.:	Albany	10	2	0	0	Jan 71	1	23	1	23	7
	Buffalo	16	1	0	0	Sept 70	0				
	New York City	0				Oct 70	0				
N.C.:	Gastonia	13	12	1	4	Sept 70	2	17	(c)		
N. Dak:	Bismarck	18	4	0	1	Dec 70	8	31	8	31	3
Ohio:	Cincinnati	0				Feb 71	0				
	Columbus	1	1	1	1	Aug 70	0				
	Painesville	10	1	0	1	July 70	6	64	6	64	10
Okla:	Oklahoma City	16	4	1	2	Nov 70	1	8	1	8	0
	Ponca City	18	15	1	3	July 70	0				
Oreg:	Portland	18	2	0	0	Jan 71	13	154	13	154	5
Pa:	Harrisburg	10	1	0	0	Feb 71	2	31	2	31	3
P.R.:	San Juan	0				Aug 70	0				
R.I:	Providence	18	1	0	0	Nov 70	4	30	4	30	1
S.C:	Columbia	16	4	0	1	Oct 70	3	124	1	11	0
S. Dak:	Pierre	18	6	0	2	Aug 70	0				
Tenn:	Nashville	17	1	0	0	Nov 70	4	55	4	55	1
Tex:	Austin	0				Feb 71	0				
	El Paso	0				Dec 70	0				
Utah:	Salt Lake City	29	4	0	1	Jan 71	9	58	8	48	8
Vt:	Barre	12	4	0	1	Mar 71	4	39	4	30	6
Va:	Richmond	18	1	0	0	Mar 71	8	115	8	115	44
Wash:	Seattle	10	0	0	0	Mar 71	8	82	(c)		
	Spokane	11	1	0	1	Feb 71	0				
W. Va:	Charleston	18	2	0	1	Oct 70	8	93	8	93	18
Wisc:	Madison	20	2	0	1	Mar 71	6	33	6	33	2
Wyo:	Cheyenne	18	4	0	1	July 70	1	3	1	3	0
Network summary		935	27	0	1		210	62	5	52	5

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] These data are suspect.
[c] This station is part of the plutonium in precipitation network. No gross beta measurements are done.

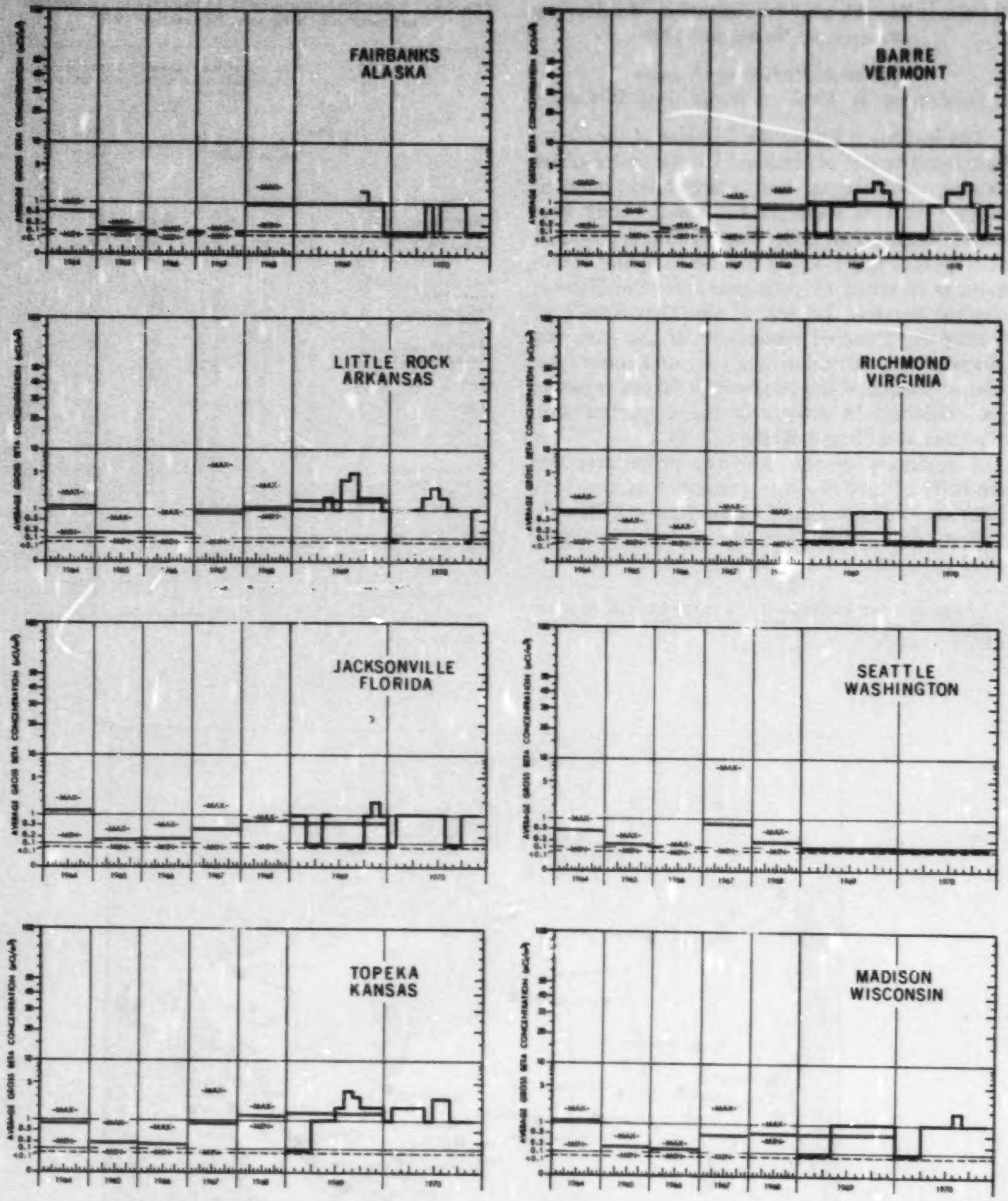


Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1964–November 1970

2. Canadian Air and Precipitation Monitoring Program[1], November 1970

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for November 1970 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, November 1970

Station	Number of samples	Air surveillance, gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	2	0.1	0.0	0.1	225	3.82
Coral Harbour	3	.1	.0	.1	7	.12
Edmonton	5	.1	.0	.1	16	.58
Ft. Churchill	5	.1	.0	.1	8	.47
Fredericton	5	.1	.1	.1	20	1.32
Goose Bay	6	.1	.0	.0	23	.83
Halifax	5	.1	.0	.1	28	2.94
Inuvik	4	.1	.1	.1	17	.25
Montreal	4	.1	.1	.1	34	2.58
Moosonee	5	.1	.1	.1	NS	NS
Ottawa	5	.1	.0	.1	24	2.06
Quebec	1	.0	.0	.0	43	4.41
Regina	9	.2	.0	.1	34	.62
Resolute	5	.2	.0	.1	NS	NS
St. John's, Nfld	5	.1	.0	.1	12	2.31
Saskatoon	5	.1	.0	.1	46	1.14
Sault Ste. Marie	5	.2	.0	.1	45	2.24
Thunder Bay	5	.2	.0	.1	24	2.05
Toronto	1	.1	.1	.1	43	1.98
Vancouver	5	.1	.0	.0	32	3.22
Whitehorse	5	.3	.1	.1	NS	NS
Windsor	5	.2	.1	.1	19	1.30
Winnipeg	5	.2	.0	.1	63	1.09
Yellowknife	5	.1	.0	.1	95	.72
Network summary	110	0.3	0.0	0.1	41	1.74

NS, no sample.

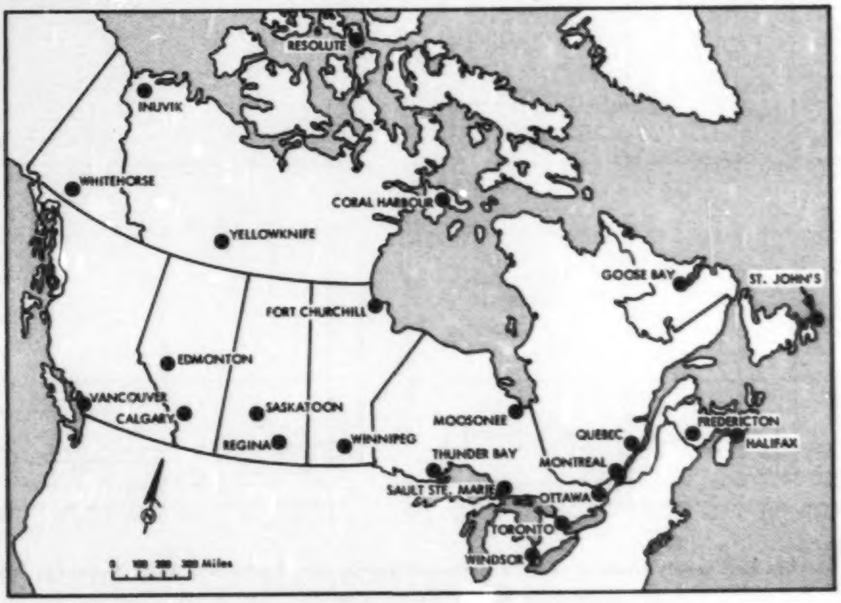

RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
0 100 200 300 Miles

Figure 3. Canadian air and precipitation sampling stations

---

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Air Sampling Program November 1970

Pan American Health Organization and *U.S. Environmental Protection Agency*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 4. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The November 1970 air monitoring results from the participating countries are given in table 3.

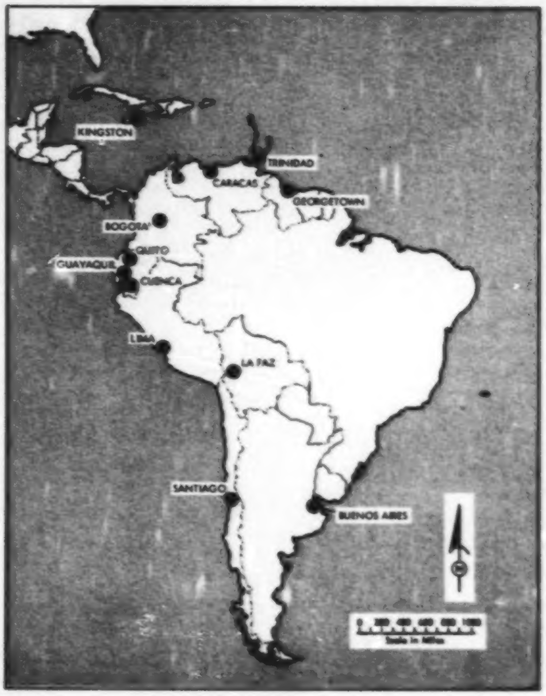


Figure 4. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, November 1970

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Argentina: Buenos Aires	0	NS	NS	NS
Bolivia: La Paz	18	1.10	0.10	0.35
Chile: Santiago	15	.40	.05	.23
Colombia: Bogota	19	.04	.01	.02
Ecuador: Cuenca	0	NS	NS	NS
Guayaquil	0	NS	NS	NS
Quito	0	NS	NS	NS
Guyana: Georgetown	8	.11	.01	.04
Jamaica: Kingston	0	NS	NS	NS
Peru: Lima	24	.57	.21	.38
Venezuela: Caracas	11	.10	.02	.06
West Indies: Trinidad	18	.10	.00	.06
Pan American summary	113	1.10	0.00	0.19

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
NS, no sample.

4. Plutonium in Airborne Particulates January–June 1970

Radiation Office
Environmental Protection Agency

The Radiation Alert Network (RAN) of the Air Pollution Control Office, Environmental Protection Agency, routinely collects airborne particulate samples from 11 selected RAN stations for plutonium analyses. The plutonium analyses were initiated in November 1965 and references to the previous results through December 1969 have been published (*6*).

One-half of each individual air filter from the selected stations is sent to the Northeastern Radiological Health Laboratory, Winchester, Mass. The laboratory analyzes a composite of these samples for each station on a quarterly basis. The results for January-June 1970 are presented in table 4. The minimum detectable activities are 20 fCi and 15 fCi per sample for plutonium-238 and plutonium-239, respectively. The volume of air samples varies, generally ranging from 20,000 to 30,000 cubic meters per month.

161

Table 4. Plutonium in airborne particulates, January–June 1970

1970	Anchorage	Phoenix	Denver	Honolulu	New Orleans	Rockville	Buffalo	Gastonia	Pierre	Austin	Seattle
Plutonium-238: (aCi/m³)											
January–March	3	10	9	8	5	5	NS	6	4	7	4
April–June	a 6	20	10	5	9	7	10	12	9	11	8
Plutonium-239: (aCi/m³)											
January–March	20	68	55	40	35	26	NS	45	34	42	31
April–June	21	190	130	50	87	82	89	120	95	110	54
^{239}Pu/^{238}Pu:											
January–March	6.7	6.8	6.1	5.0	7.0	5.2	—	7.5	8.5	6.0	7.8
April–June	3.5	9.5	8.1	10.0	9.7	11.7	8.9	10.0	10.6	10.0	6.8

[a] Composite for May and June only.
NS, no sample.

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*6*) BUREAU OF RADIOLOGICAL HEALTH. Plutonium of airborne particulates, April–December 1969. Radiol Health Data Rep 11:552–553 (October 1970).

162

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Feed Materials Production Center and Paducah Plant.

---

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Feed Materials Production Center January–June 1970

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the Atomic Energy Commission (AEC). The location as related to populated areas is shown in figure 1. Cincinnati and Hamilton, the larger nearby communities, are situated 20 and 10 miles from FMPC, respectively. Operations at this project are concerned with the processing of high-grade uranium concentrates into metallic uranium. These processes include acid digestion of the concentrates, organic phase extraction of uranyl nitrate, subsequent conversion of the uranyl nitrate to uranium oxide and tetrafluoride, reduction to uranium metal, and fabrication of the metal into fuel elements.

---

[1] Summarized from "Feed Materials Production Center Environmental Monitoring Semiannual Report for the First Half of 1970" (NLCO-1073).

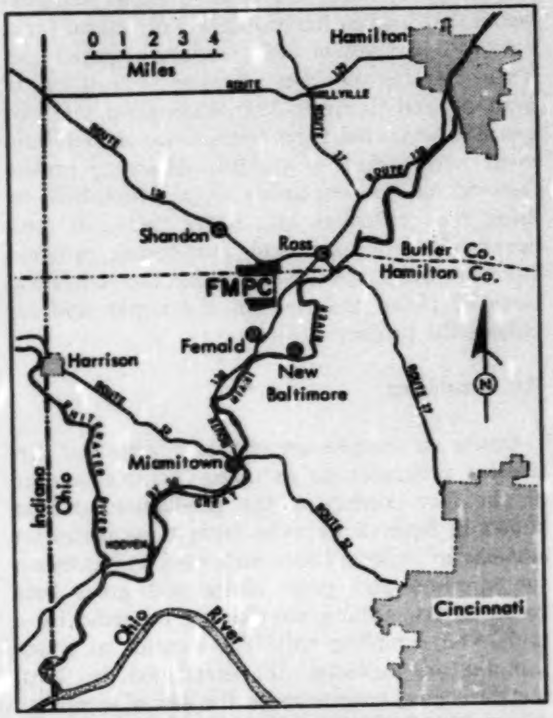


Figure 1. Area map of Feed Materials Production Center

Table 1. Radioactivity levels of airborne particulates, Feed Materials Production Center, January–June 1970

Location	Number of samples	Uranium concentration[a] (pCi/m³)			Alpha radioactivity[b] (pCi/m³)			Beta radioactivity[c] (pCi/m³)		
		Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Onsite:										
Southwest	26	0.9	<0.1	0.1	0.9	<0.1	0.2	1.4	<0.1	0.7
Northwest	26	.1	< .1	< .1	.1	< .1	< .1	.4	< .1	.1
Northeast	26	.3	< .1	< .1	.3	< .1	< .1	.7	< .1	.2
Southeast	26	.1	< .1	< .1	.1	< .1	< .1	.4	< .1	.1
All onsite samples	104			0.1			0.1			0.3
Offsite:										
0–2 miles from FMPC	12	<0.1	< .1	< .1	<0.1	< .1	<0.1	0.2	<0.1	<0.1
2–4 miles from FMPC	12	< .1	< .1	< .1	< .1	< .1	< .1	.2	< .1	< .1
4–8 miles from FMPC	17	< .1	< .1	< .1	< .1	< .1	< .1	.4	< .1	.1
8–12 miles from FMPC	4	.1	< .1	< .1	.1	< .1	< .1	.6	.6	.6
All offsite samples	45			<0.1			<0.1			0.1

[a] AEC radiation protection standard—2 pCi/m³.
[b] AEC radiation protection standard—2 pCi/m³.
[c] AEC radiation protection standard—1 nCi/m³ (thorium-234).

During the past 2 years, the project has also processed thorium to produce purified oxide and metal. The process of these products is essentially the same as used in producing uranium.

During the many involved reactions and processes that lead to the production of reactor fuels, various liquid and airborne wastes are generated. These wastes contain varying quantities of uranium and thorium. Various in-plant methods are used to curtail their release into the environment surrounding the plant. Almost complete removal of the materials is accomplished by using dust collectors and waste treatment processes. An environmental monitoring program has been established to determine the concentrations of plant materials in the water and air outside the project.

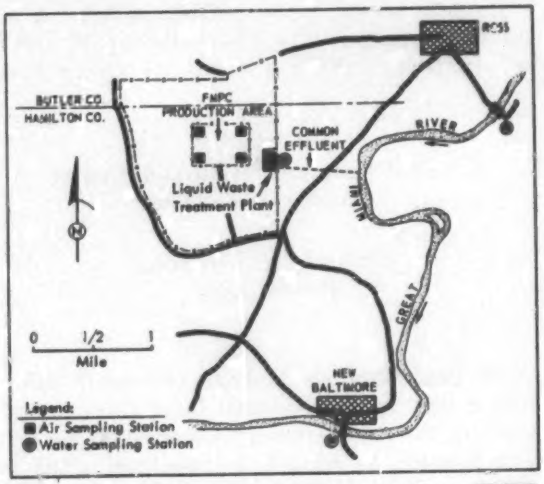


Figure 2. Air and water sampling stations, FMPC

Air monitoring

Onsite air samples are obtained from four permanent perimeter air sampling stations, located at the four corners of the production area as shown in figure 2. Samples from these perimeter stations are collected once each week and analyzed for uranium and gross alpha and gross beta radioactivity. Offsite samples are collected by a mobile air sampling unit. The location at which samples are collected is determined by local meteorological conditions on the day of sampling. Approximately 80 percent of all samples are taken downwind of the FMPC plant. Replicate samples are taken at each sampling point and averaged to obtain a representative concentration for that location. An analysis for thorium is not considered necessary because of the small amount of thorium handled in the project. Concentrations of uranium and alpha and beta radioactivity of airborne particulates sampled at onsite and offsite locations are given in table 1.

The results of sampling indicate that the concentrations at onsite locations averaged 5 per-

164

cent, 5 percent, and 0.02 percent of the AEC standards for uranium, alpha radioactivity, and beta radioactivity, respectively; the offsite concentrations averaged 5 percent, 5 percent, and 0.01 percent of the AEC standards for uranium, alpha radioactivity, and beta radioactivity.

Water monitoring

Each of the individual production plants on the project has collection sumps and treatment equipment to remove the uranium from the process wastewater. The effluents from the plants are collected at a general sump for additional treatment and settling. The clear water from the sump is pumped to the river. The solid portion is pumped to a chemical waste pit for further settling. The clear effluent from the pit is then combined with three other types of project wastewater and discharged via a common effluent outfall into the Great Miami River. A Parshal-Flume-type water sampler collects samples of the combined effluent stream, which are removed and analyzed daily. These results are utilized with measurements of river flow in calculating the radioactive contaminant concentrations added to the river. Weekly spot samples are obtained upstream; a continuous sample is taken for a 24-hour period downstream, and at least one sample is analyzed each week. Samples of the storm sewer overflow are collected in an automatic flow integrated sampler when overflow occurs. All samples are analyzed for uranium, gross alpha, and gross beta radioactivity and radium-228, a daughter of thorium-232. Since radium-228 has the most restrictive AEC standard, control of this radionuclide and of the gross radioactivity insures that the AEC standards for the thorium decay chain are not exceeded.

The average concentrations of all sampled contaminants at the downstream position indicate that each contaminant was well below the AEC standard. It may be concluded from sampling and calculations that the FMPC effluent produced little change in the river's quality. The results of the FMPC water monitoring program for January–June 1970 are summarized in table 2.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1969	March 1970
July–December 1969	August 1970

Table 2. Radioactivity in the Great Miami River, Feed Materials Production Center, January–June 1970

Location	Number of samples	Uranium[a] (pCi/liter)			Alpha radioactivity[b] (pCi/liter)			Beta radioactivity[b] (pCi/liter)			Number of samples	Radium-228[c] (pCi/liter)		
		Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average		Maximum	Minimum	Average
Sewer outfall[d]	181	<10	<10	<10	<10	<10	<10	20	<10	<10	9	1.01	.10	.39
Upstream from outfall	27	50	<10	<10	60	<10	10	50	<10	20	6	9.10	.45	2.56
Downstream from outfall	27	40	<10	<10	50	<10	<10	60	<10	20	6	1.36	.45	1.04

[a] AEC standard—20 nCi/liter.
[b] AEC standard—3 nCi/liter.
[c] AEC standard—30 pCi/liter.
[d] Concentrations in the river as calculated from sewer outfall sample results.

2. Paducah Plant[1]
January–June 1970

Union Carbide Corporation
Paducah, Ky.

The Paducah Plant is a government-owned gaseous diffusion plant operated by the Nuclear Division of the Union Carbide Corporation for the Atomic Energy Commission. The diffusion plant processes large quantities of relatively pure uranium compounds. The uranium hexafluoride manufacturing plant, a former source of diffusion plant feed which was placed on standby in June of 1964, was reactivated in August 1968. Parts of the associated uranium metal foundry, usually on standby, are operated infrequently as the need arises. A decontamination and uranium recovery facility operates to prepare equipment for repair and to recover impure or scrap uranium materials. Depleted uranium metal is fabricated into shields, weights, ballasts, or other shapes on a nonroutine basis. The major sources of external penetrating radiation are the daughter products of uranium, thorium-234 and protactinium-234, which may be concentrated by uranium recovery processes or by uranium hexafluoride vaporization. The element uranium can be a physiological hazard only if allowed to enter the body. The chemical toxicity of the uranium processed at the Paducah Plant overshadows any probable biological effects of radiation from this element, thus making it comparable as a physiological hazard to lead, mercury, or other well-known heavy metals.

The uranium enrichment areas (cascade) operate with a very low loss of material. Millions of pounds of uranium hexafluoride may be fed to, diffused in, and withdrawn from the cascade with the loss of only a few pounds per year. There is a slight loss of uranium to the atmosphere when diluent gases are purged from equipment units or from the cascade. Some uranium on cascade equipment replaced for maintenance or modification is removed in the decontamination facility.

Effluents from the uranium hexafluoride manufacturing plant are more significant than those of the diffusion cascade. The transfer of powdered uranium salts between the numerous processing reactors and intermediate storage facilities requires extensive use of vacuum or local exhaust systems. Various bag and pleated filter units are used to remove uranium from exhaust air. The product uranium hexafluoride is separated from entrained solids, excess fluorine, and diluent gases by a series of filters, cold condensers, and fluid bed absorbers. A small fraction of the input to this plant constituting a significant amount of uranium is not reacted to uranium hexafluoride

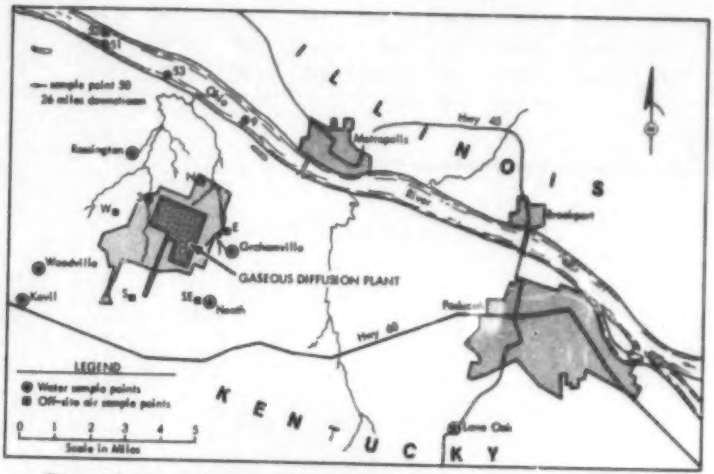


Figure 3. Sampling locations, Paducah Gaseous Diffusion Plant

and must be processed through uranium recovery at the decontamination facility. Beta emitting uranium decay products which separate from the uranium hexafluoride at fluorination are also in this material flow.

---

[1] Summarized from "Environmental Concentrations of Radioactive Materials near the Paducah Plant—Report for the First Half of 1970."

The environmental monitoring program provides for continuously sampling the air at four stations around the plant perimeter fence, and at five stations located approximately 1 mile outside this fence (figure 3). Big Bayou and Little Bayou waters are sampled continuously, and grab samples are collected at five locations in the Ohio River. In addition, gamma radiation readings are taken each month at each of the air sampling stations with a Geiger-Mueller type meter 3 feet above ground level.

Table 3. Uranium concentrations in outdoor air samples, Paducah Plant, January–June 1970

Sample location[a]	Number of samples	Uranium alpha radioactivity[b] (pCi/m³)		
		Maximum	Minimum[c]	Mean[d]
At plant perimeter fence:				
North	26	0.08	<0.02	0.02
East	26	.29	< .02	.04
South	26	.02	< .02	< .02
West	26	.05	< .02	< .02
Summary	104	0.29	<0.02	0.02
About 1 mile outside plant perimeter fence:				
North	26	0.02	0.02	<0.02
East	26	.04	< .02	< .02
South	26	.02	< .02	< .02
West	26	.02	< .02	< .02
Southeast	26	.02	< .02	< .02
Summary	130	0.04	<0.02	<0.02

[a] See figure 3.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57 × 10⁴ alpha dis/s.
[c] The minimum detectable concentration of uranium in air is 0.02 pCi/m³.
[d] The AEC standard for natural uranium in air released to the environs beyond a controlled area is 2 pCi/m³.

Basic standards

The radiation protection standards observed for the in plant work environment of employees and for offsite exposure of the general population are those contained in Appendix 0524 of the AEC manual.

Discussion

Data summarizing the environmental concentrations of radioactive materials in air and water and the gamma radiation levels in the vicinity

Table 4. Beta radioactivity in outdoor air samples Paducah Plant, January–June 1970

Sample locations[a]	Number of samples	Beta radioactivity (pCi/m³)		
		Maximum	Minimum[b]	Mean[c]
At plant perimeter fence:				
North	26	3.3	<0.1	0.86
East	26	1.5	< .1	.45
South	26	.63	< .1	.20
West	26	.86	< .1	.47
Summary	104	3.3	<0.1	0.47
About 1 mile outside plant perimeter fence:				
North	26	1.2	<0.1	0.27
East	26	.72	< .1	.22
South	26	.77	< .1	.23
West	26	.63	< .1	.23
Southeast	26	.72	< .1	.24
Summary	130	1.2	<0.1	0.24

[a] See figure 3.
[b] The minimum detectable amount of beta-particle emitters in air is 0.1 pCi/m³.
[c] The AEC standard for immediate daughter products of uranium in air is 1 nCi/m³ (standard for thorium-234).

Table 5. Concentrations of uranium in water, Paducah Plant, January–June 1970

Sample locations[a]	Number of samples	Uranium[b] (pCi/liter)		
		Maximum	Minimum[c]	Mean[d]
Big Bayou 3	26	31	1	8
Little Bayou 17	26	280	13	50
Ohio River 9	4	<1	<1	<1
Composite of 50, 51, 52 and 53	4	2	<1	<1

[a] See figure 3.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57 × 10⁴ alpha dis/s.
[c] The minimum detectable concentration of uranium in water is 1 pCi/liter.
[d] The AEC standard for natural uranium in water beyond a controlled area is 20 nCi/liter.

Table 6. Concentration of beta-particle emitters in water, Paducah Plant, January–June 1970

Sample locations[a]	Number of samples	Beta-particle emitters (pCi/liter)		
		Maximum	Minimum[b]	Mean[c]
Big Bayou 3	26	300	<100	<100
Little Bayou 17	26	8,200	<100	1,000
Ohio River 9	4	400	<100	100
Composite of 50, 51, 52 and 53	4	200	100	<100

[a] See figure 3.
[b] The minimum detectable amount of beta-particle emitters in water is 100 pCi/liter.
[c] The AEC standard for the immediate daughter products of uranium in water beyond a controlled area is 20 nCi/liter.

Table 7. External gamma radiation levels January–June 1970

Sample locations[a]	Number of readings	Average gamma radiation (mR/h)
At plant perimeter fence:		
North	5	0.02
East[b]	5	.04
South	5	.02
West	5	.02
Total	20	0.02
About 1 mile outside plant perimeter fence:		
North	5	0.02
East	5	.02
South	5	.02
West	5	.02
Southeast	5	.02
Total	25	0.02

[a] See figure 3.
[b] Near uranium hexafluoride cylinder storage area.

of the Paducah Gaseous Diffusion Plant are presented in tables 3 through 7.

Air samples were collected continuously at each of the four stations at the plant perimeter fence and at five stations about 1 mile outside the plant. Air is filtered at 0.3 cfm through 2-inch diameter membrane filters which are replaced weekly and counted for alpha and beta radioactivity.

The average alpha particle count—interpreted as uranium, the most likely source of radioactivity—of the 234 air samples collected during January–June 1970 was 1.0 percent of the AEC standard set for individuals residing in the vicinity of a controlled area. The average beta particle count of the same samples was 0.04 percent of the AEC standard.

The average uranium analyses of weekly water samples collected continuously from Big and Little Bayous during January–June 1970 were 0.04 and 0.28 percent, respectively, of the AEC standard for water beyond a controlled area. The average result of the uranium analyses for each of the 5 grab samples collected at monthly intervals from the Ohio River below the plant was less than 0.01 percent of the AEC standard.

The concentration of beta-particle emitters in the Big and Little Bayous averaged less than 0.5 percent and 5 percent, respectively, of the AEC standard for the decay products of uranium-238 during the January–June 1970 period. The average beta radioactivity of the Ohio River was less than 0.5 percent of the standard for uranium-238 decay products.

External gamma radiation in the vicinity of the Paducah Plant averaged 0.02 mR/h at all sampling stations for January–June 1970, except for the east plant perimeter station which had an average of 0.04 mR/h.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1969	April 1970
July–December 1969	September 1970

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,064,500	Tennessee Valley Authority	1972
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,064,500	Tennessee Valley Authority	1972
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,064,500	Tennessee Valley Authority	1973
Dothan	Joseph M. Farley Nuclear Plant: Unit 1	829,000	Alabama Power Co.	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 2	829,000	Alabama Power Co.	1977
ARKANSAS				
London	Arkansas Nuclear One: Unit 1	820,000	Arkansas Power & Light Co.	1973
London	Arkansas Nuclear One: Unit 2	950,000	Arkansas Power & Light Co.	1975
CALIFORNIA				
Humboldt Bay	Humboldt Bay Power Plant: Unit 3	68,500	Pacific Gas & Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1967
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1975
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1977
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,060,000	Pacific Gas & Electric Co.	1973
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,060,000	Pacific Gas & Electric Co.	1974
Clay Station	Rancho Seco Nuclear Generating Station	804,000	Sacramento Municipal Utility District	1972
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1972
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1967
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1970
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
FLORIDA				
Turkey Point	Turkey Point Station: Unit 3	651,500	Florida Power & Light Co.	1971
Turkey Point	Turkey Point Station: Unit 4	651,500	Florida Power & Light Co.	1972
Red Level	Crystal River Plant: Unit 3	858,000	Florida Power Corp.	1972
Ft. Pierce	Hutchinson Island: Unit 1	813,000	Florida Power and Light Co.	1973
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1973
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	786,000	Georgia Power Co.	1976
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	800,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	800,000	Commonwealth Edison Co.	1971
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co	1972
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1973
Cordova	Quad-Cities Station: Unit 1	800,000	Comm. Ed. Co.–Ia.–Ill. Gas & Elec. Co	1971
Cordova	Quad-Cities Station: Unit 2	800,000	Comm. Ed. Co.–Ia.–Ill. Gas & Elec. Co.	1972
Seneca	LaSalle Co. Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co.–Ia.	1975
Seneca	LaSalle Co. Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co.–Ia.	1976
INDIANA				
Dune Acres	Bailly Generating Station	660,000	Northern Indiana Public Service Co.	1976
IOWA				
Cedar Rapids	Duane Arnold Energy Center: Unit 1	545,000	Iowa Electric Light and Power Co.	1973
LOUISIANA				
Taft	Waterford Generating Station: Unit 3	1,165,000	Louisiana Power & Light Co.	1976
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	800,000	Baltimore Gas and Electric Co.	1973
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	800,000	Baltimore Gas and Electric Co.	1974
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station	654,000	Boston Edison Co.	1971
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co.	1963
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1970
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 1	60,900	Detroit Edison Co.	1970
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,123,000	Detroit Edison Co.	1973
Bridgman	Donald C. Cook Plant: Unit 1	1,054,000	Indiana & Michigan Electric Co.	1973
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1974
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1974
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1975
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1970
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1972
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974

---

* Site not selected.

*	—	1,201,000	Tennessee Valley Authority	1977
*	—	1,201,000	Tennessee Valley Authority	1978

Figure 1. Nuclear power plants in the United States

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1972
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1972
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	560,000	Jersey Central Power & Light Co.	1969
Lacey Township	Forked River Generating Station: Unit 1	1,140,000	Jersey Central Power & Light Co.	1975
Salem	Salem Nuclear Generating Station: Unit 1	1,090,000	Public Service Electric and Gas, N. J.	1972
Salem	Salem Nuclear Generating Station: Unit 2	1,090,000	Public Service Electric and Gas, N. J.	1973
Newbold Island	Newbold Nuclear Generating Station: Unit 1	1,068,000	Public Service Electric and Gas, N. J.	1975
Newbold Island	Newbold Nuclear Generating Station: Unit 2	1,068,000	Public Service Electric and Gas, N. J.	1977
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1963
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1971
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1973
Scriba	Nine Mile Point Nuclear Station	500,000	Niagara Mohawk Power Co.	1970
Rochester	R. E. Ginna Nuclear Power Plant: Unit 1	420,000	Rochester Gas & Electric Co.	1970
Brookhaven	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1975
Lansing	Bell Station	838,000	New York State Electric & Gas Co.	1978
Verplanck	Verplanck: Unit 1	1,115,000	Consolidated Edison Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N.Y.	1973
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1976
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
*		821,000	Carolina Power and Light Co.	—
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 1	1,150,000	Duke Power Co.	1976
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 2	1,150,000	Duke Power Co.	1978
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station	872,000	Toledo Edison-Cleveland Electric Illuminating Co.	1974
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1974
OREGON				
Rainier	Trojan Station	1,130,000	Portland General Electric Co.	1974
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1972
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1973
Pottstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1976
Pottstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1977
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	847,000	Duquesne Light Co.–Ohio Edison Co.	1973
Middletown	Three Mile Island Nuclear Station: Unit 1	810,000	Metropolitan Edison Co.	1972
Middletown	Three Mile Island Nuclear Station: Unit 2	810,000	Jersey Central Power & Light Co.	1974
Berwick	Susquehanna Steam Electric Station: Unit 1	1,052,000	Pennsylvania Power and Light	1977
Berwick	Susquehanna Steam Electric Station: Unit 2	1,052,000	Pennsylvania Power and Light	1979
SOUTH CAROLINA				
Hartsville	H. B. Robinson S. E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1971
Seneca	Oconee Nuclear Station: Unit 1	841,000	Duke Power Co.	1971
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1972
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1973
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,124,000	Tennessee Valley Authority	1974
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,124,000	Tennessee Valley Authority	1974
Rhea County	Watts Bar Nuclear Plant: Unit 1	1,170,000	Tennessee Valley Authority	1976
Rhea County	Watts Bar Nuclear Plant: Unit 2	1,170,000	Tennessee Valley Authority	1977
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.-Green Mt. Power Corp.	1971
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	780,000	Virginia Electric & Power Co.	1971
Gravel Neck	Surry Power Station: Unit 2	780,000	Virginia Electric & Power Co.	1972
Mineral	North Anna Power Station: Unit 1	845,000	Virginia Electric & Power Co.	1974
Mineral	North Anna Power Station: Unit 2	845,000	Virginia Electric & Power Co.	1975
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	790,000	Washington Public Power Supply System	1966
WISCONSIN				
Genoa	LaCrosse Boiling Water Reactor	50,000	Dairyland Power Cooperative	1969
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1970
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1971
Carlton	Kewaunee Nuclear Power Plant: Unit 1	527,000	Wisconsin Public Service Co.	1972
PUERTO RICO				
Central Aguirre	Aguirre Nuclear Power Plant	583,000	Puerto Rico Water Resources Authority	1975

Figure 1. Nuclear power plants in the United States—continued

170

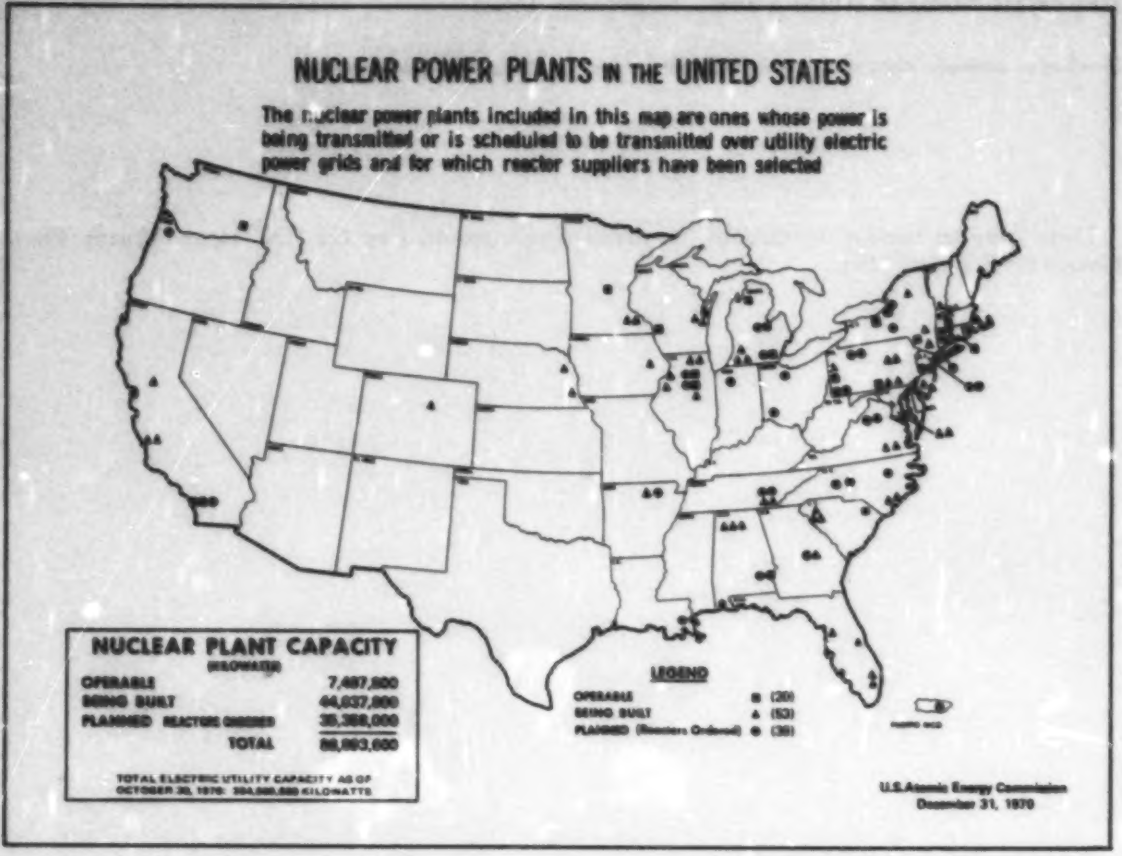

NUCLEAR POWER PLANTS IN THE UNITED STATES
The nuclear power plants included in this map are ones whose power is being transmitted or is scheduled to be transmitted over utility electric power grids and for which reactor suppliers have been selected
NUCLEAR PLANT CAPACITY
(KILOWATTS)
OPERABLE 7,487,800
BEING BUILT 44,037,800
PLANNED REACTORS ORDERED 35,368,000
TOTAL 86,893,600
TOTAL ELECTRIC UTILITY CAPACITY AS OF OCTOBER 30, 1970: [illegible] KILOWATTS
LEGEND
OPERABLE ■ (20)
BEING BUILT ▲ (53)
PLANNED (Reactors Ordered) ● (36)
PUERTO RICO
U.S.Atomic Energy Commission
December 31, 1970

Figure 1. Nuclear power plants in the United States—continued

171

Reported Nuclear Detonations, February 1971

(Includes seismic signals presumably from foreign nuclear detonations)

There were no nuclear detonations or seismic signals reported by the U.S. Atomic Energy Commission for February 1971.

Information in this section is based on data received during the month, and is subject to change as additional information may become available. Persons requiring information for purposes of compiling announced nuclear detonation statistics are advised to contact the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

172

ERRATA

In the article entitled "Radioactive Cesium in Estuaries" that appeared in the December 1970 issue of *Radiological Health Data and Reports*, an error occurred in the first paragraph of the second column on page 661. The first sentence should read:

"The Patuxent River (table 4) has a cesium-137 distribution similar to that of the bay; that is, the ratio of cesium-137 to salinity is about *0.02* in the surface water and about *0.01* near the bottom."

On page 665, reference 5, should be corrected to read:

(5) GROSS, M. G. New York City--A major source of marine sediment, . . .

Authors note: The cesium-137 data obtained from references 6 and 7 were estimated from strontium-90 data using a cesium to strontium ratio of 1.5.

On page 693 of the December 1970 issue, a topographical error occurred in table 1 of the article, "Tritium in Community Water Supplies, 1969." The tritium concentration in the sample for Pueblo, Colo., collected from 6/13 to 6/26 should be changed from 2.0 ± 0.2 to 1.0 ± 0.4 nCi/liter.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the conveneince of readers who may wish to clip them for their files.

SUMMARY OF ENVIRONMENTAL MONITORING AT AMES LABORATORY, 1962–1969. *J. J. Copp. Radiological Health Data and Reports, Vol. 12, February 1971*, pp. 119–128.

The Ames Laboratory Research Reactor facility (ALRR), operated for the U.S. Atomic Energy Commission by the Iowa State University of Science and Technology, reached full power in July 1965. The preoperational and present environmental monitoring program consists of gross alpha and gross beta radioactivity determinations of air, soil, vegetation, river water, ALRR outfall, river bottom sediment, precipitation, well water, and pond water samples.

The average beta radioactivity levels in air ranged from 3.86 pCi/m^3 in 1963 to 0.12 pCi/m^3 in 1967. The 1964 average level of beta radioactivity (1.26 pCi/m^3) was about one-third of the 1962–1963 average levels.

The beta radioactivity in soil increased from 1962 to a peak of 20 pCi/g in 1964, probably due to weapons fallout, then decreased to a plateau of 13–15 pCi/g in 1965 through 1969. The alpha radioactivity increased from 1962 to 1964 and leveled to a plateau (1964–1969) of 0.7–1.0 pCi/g.

Vegetation samples showed decreasing levels of beta radioactivity to 20–30 pCi/g. The alpha radioactivity in vegetation was variable with a general decrease from 1962 to 1965, leveling to 0.1–0.2 pCi/g in 1966–1968 and showing a rise to 0.91 pCi/g in 1969.

Beta radioactivity concentrations in suspended solids of collected water samples ranged from the maximum of 248 pCi/liter in 1963 to a minimum of 4.70 pCi/liter in 1967.

The environmental data indicate that any radiation that may have been contributed to the environment by the Ames Laboratory Research Reactor facility could not be detected.

KEYWORDS: Air, Iowa, precipitation, radionuclides, reactor, soil, surveillance, vegetation, water.

RESULTS OF RADIATION SAFETY SURVEYS OF X-RAY FACILITIES WITHIN THE BUREAU OF PRISONS AND FEDERAL HEALTH PROGRAMS SERVICE. *Lois A. Miller* and *LaVert C. Seabron. Radiological Health Data and Reports, Vol. 12, March 1970*, pp. 129–135.

This report presents the results of comprehensive surveys of x-ray facilities in 26 Bureau of Prison installations and in 11 hospitals and 20 outpatient clinics of the Public Health Service throughout the United States. Facility workloads, types of equipment, operator training, and equipment deficiencies are discussed.

KEYWORDS: Collimation, dental x-ray facilities, diagnostic x-ray equipment, filtration, fluoroscopic machines, radiographic machines, radiation surveys, United States, x-ray.

COLOR TELEVISION SURVEY IN PENNSYLVANIA. *Richard A. Lane. Radiological Health Data and Reports, Vol. 12, March 1971*, pp. 137–138.

During 1968–1970, 322 color television sets in Pennsylvania were surveyed for emissions of x radiation. Eighty-seven percent were found to emit radiation less than or equal to 0.1 mR/h. Two percent emitted radiation in excess of 0.5 mR/h. It was determined from the survey that the primary cause for leakage from color television sets is related to high voltage adjustments. It was found that two of the sets emitting radiation in excess of 0.5 mR/h were serviced shortly before the investigation. Voltage readings as high as 39 kV were observed.

KEYWORDS: Color television, Pennsylvania, survey, x-ray

☆ U.S. GOVERNMENT PRINTING OFFICE: 1971—[illegible]/8